APPENDIX A

PM_{10} GRASEBY/ANDERSON/GMW HI-VOLUME SAMPLER

STATE OF IDAHO

DEPARTMENT OF ENVIRONMENTAL QUALITY

AIR MONITORING QUALITY ASSURANCE

STANDARD OPERATING PROCEDURES

FOR

AIR QUALITY MONITORING

MONITORING, MODELING, AND EMISSIONS INVENTORY

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Acronyms, Units, And Chemical Nomenclature

AQS	Air Quality System
ASTM	American Society for Testing and Materials
EPA	Environmental Protection Agency
Hi-Vol	high volume
m^3/min	cubic meters per minute
Mm	Millimeters (10^{-3} m)
mm Hg	Millimeters of mercury
µm	Micrometers (10^{-6} m)
µg/m^3	Micrograms per cubic meter
NAAQS	National Ambient Air Quality Standards
NIST	National Institute of Standards and Technology
NWS	National Weather Service
PM_{10}	Particulate Matter with a Mean Aerodynamic Diameter of 10 µg or less
QA	Quality Assurance
SOP	Standard Operating Procedure
SSI	size selective inlet
VFC	Volumetric Flow Control

A.1 GENERAL INFORMATION

The reference method for high volume PM_{10} (particulate matter with an aerodynamic diameter of 10 micrometers [µm] and less) sampling is found in 40 CFR Part 50, Appendix J. Sampler siting, operation, and quality assurance (QA) regulations are presented in 40 CFR Part 58, Appendix E. A good guideline for site selection is *Network Design and Optimum Site Exposure Criteria for Particulate Matter (EPA-450/4-87-009)*. The sampler is essentially portable, requiring only a 115 volt, 10 amp AC outlet (the motor draws approximately 7 amps maximum). The operating procedures presented in this standard operating procedure (SOP) are derived from the cited regulations and the guidance presented in the manufacturer's instructions and the U.S. Environmental Protection Agency's (EPA) *Quality Assurance Handbook for Air Pollution Measurement Systems,* Section 2.12.

A.1.1 Specifications

STANDARDS:	State:	Federal standards adopted by Idaho
	Federal:	Primary and Secondary
		150 µg/m^3, 24 (±1 hour) hour block average (midnight-midnight local standard time)
		50 µg/m^3 annual arithmetic mean
METHOD:		Graseby/Anderson/GMW High Volume Sampler Model G1200 size selective inlet
FLOW CONTROL TYPE:		Graseby/Anderson/GMW Sampler Volumetric Flow Control (VFC)
PROCEDURE:		High volume impaction
FILTER MEDIUM:		Quartz
RANGE:		2-500 µg/m^3; flow rate 1.13 actual m^3/min (±10%)
MANUFACTURER:		Graseby/Anderson/GMW

A.1.2 Principles of Operation

A high volume (Hi-Vol) PM_{10} sampler (see figure A.1.1) consists of two basic components:

1) a specially designed size selective inlet (SSI) that, in theory, permits passage only of particles 10 micrometer (µm) and less in aerodynamic diameter, and

2) a flow control system capable of maintaining a constant volumetric flow rate within the design specifications of the inlet (1.13 actual cubic meters per minute [m^3/min]).

Two common types of flow control systems are available: the Mass Flow Control (MFC) and the Volumetric Flow Control (VFC) systems. This section discusses the VFC system used by the Department of Environmental Quality (DEQ).

The VFC Hi-Vol operates by pulling a determinable volume of ambient air at a constant volumetric flow rate through the SSI. Particle separation in the inlet occurs by inertial impaction. This is accomplished by forcing the air stream around a turn where the larger particles are forced by inertia from the sample stream and removed by impaction onto a greased shim. The smaller particles (10 μm and smaller) are carried with the sample stream and collected on an 8 inch x 10 inch quartz filter that is weighed before and after sampling to determine the total mass collected. The "clean air" downstream of the filter is pulled through the VFC and motor and then exits through a plenum on the motor housing.

It is important to understand that the particles are not separated discreetly. That is, some particles larger than 10 μm in diameter are not removed from the air stream and reach the filter. However, particle separation is *most efficient* when the inlet is operating at the design flow rate of 1.13 actual m^3/min and when the inlet and impaction shim are clean. If the impaction shim is not kept clean, particle "bounce off" occurs and large particles are re-entrained into the air stream and removed by the filter. When this happens, the PM_{10} measurement is biased high. Because of this, it is important that an adequate maintenance schedule is employed to ensure that the Hi-Vol motor is in good operating condition and that the inlet is cleaned regularly.

The VFC on a Hi-Vol sampler is simply a tube called a choked venturi that connects the filter assembly to a downstream vacuum motor. Flow control is achieved by restricting, or occluding the airflow through a venturi. This causes the airflow to accelerate. Bernoulli's law of physics states that the limiting velocity of air through the venturi is the acoustic velocity (speed of sound). Provided that the downstream vacuum is sufficiently large, the volume of air flowing through the venturi is a function of the internal diameter of the venturi, and the temperature of the air. The advantages of a VFC system are:

1) the volumetric flow is controlled without moving parts or electronic components,
2) the volumetric flow rate is unaffected by small changes in downstream conditions,
3) the volumetric flow rate is a predictable function of upstream air temperature, and
4) the flow rate stability is better than with other methods.

A.1.3 General Hardware

In addition to the two basic components of a VFC Hi-Vol PM_{10} sampler (the venturi and filter), ancillary components include:

1) the vacuum motor,
2) a six or seven day timer which allows the operator to set up the sampler several days ahead of the scheduled sample period,
3) a flow event recorder (sometimes referred to as a pressure transducer) that traces the flow on a circular chart and enables the operator to determine if the sampler ran steady and uninterrupted for the full sample period,
4) a filter cassette for holding the filter in place during sampling, and
5) an elapsed time indicator for measuring the total run time.

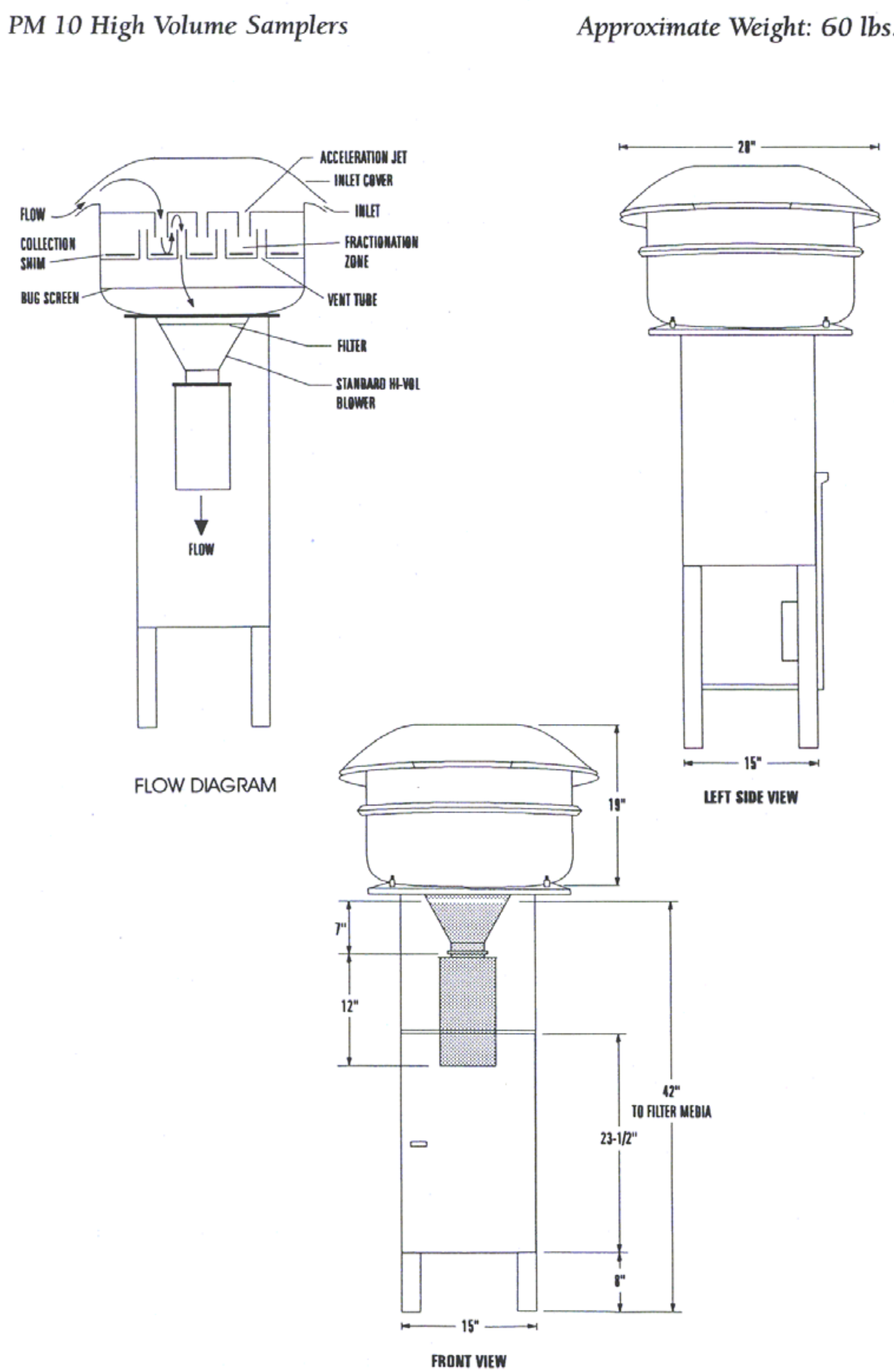

Figure A.1.1 Graseby/Anderson/GMW High Volume PM_{10} Sampler Diagram.

A.2 SAMPLE FREQUENCY

The PM_{10} samplers are operated on a schedule determined by 40 CFR Part 58, Subpart B, Section 58.13. The National Ambient Air Quality Standards (NAAQS) revision published in the July 18, 1997, Federal Register requires a minimum sampling frequency of once every third day to coincide with the national particulate sampling schedule of once every sixth day. Less frequent sampling can be approved by the EPA Regional Administrator through a waiver request.

The sampling duration for each sampling period is 24 hours, midnight to midnight ± 1 hour, local standard time, with sampler on and off times within 30 minutes of midnight. Any samples inadvertently taken on the incorrect sample day are still valid, but must be documented. Documentation should accompany the "Suspended Particulate Data Entry Form" (see Figure A.2.1) when it is submitted to the ambient air quality monitoring program at the DEQ State Office.

At those sites where the filter will be analyzed for other chemical constituents, the filters used must meet EPA's stated limits for trace elements. These limits may change annually so old filters or "off brands" may not be suitable for use at such sites. If any questions arise about EPA's current filter specifications, contact the DEQ State Office or EPA.

SUSPENDED PARTICLE DATA ENTRY FORM / STAG. PORT MANOMETER

NAME **AIRS #** **TYPE** **MONTH** **YEAR**

VFC

SAMPLER #
TO LAB
FROM LAB

RUN #	1	2	3	4	5	6	7	8
FILTER NUMBER								
Date								
Technician name								
RUN TIME								
TIME Load (min)								
TIME Unload (min)								
RUNTIME(min)								
STAG. PORT								
mmH2O Load								
mmH2O Unload								
PstgAve(mmHg)								
RUN DAY MET.								
Temp. (C)								
Temp. (K)								
P ave. (mb)								
P ave.(mm.Hg)								
C.F.								
Prat and CALIB.								
Pressure Ratio								
CALIB.Slope								
CALIB.Intcpt								
FLOWS (cu.m/min)								
Qstd								
Qact								
NET WEIGHT (mg)								
Particle								
RESULTS (µg/cu.m)	**STANDARD FLOW**							
Particle (81102)								
RESULTS (µg/cu.m)	**ACTUAL FLOW**							
Particle (85101)								

Qact={[Prat·b]*[Tav]½}*{1/m}
Qstd= Qact*CF

POLL	POC	INT	UNITS	METHOD	FREQ	START	DECIMAL
81102	1	7	001	063	6	0	0
85101	1	7	105	063	6	0	0

COMMENTS
RUN 1
RUN 2
RUN 3
RUN 4
RUN 5
RUN 6
RUN 7
RUN 8

Figure A.2.1. Suspended Particulate Data Entry Form

A.3 SAMPLER CALIBRATION

A calibration is the numerical relationship between the sampler output (volumetric flow rate) and its flow indicator (stagnation pressure ratio). It is used to determine the volumetric flow rate for a given sample period. The stagnation pressure is an area of low pressure underneath the filter caused by the resistance to airflow through the filter. The stagnation pressure ratio is a mathematical relationship of the stagnation and ambient pressures. The equation used to calculate the stagnation pressure ratio is given below in the calibration procedures (Equation 4).

For the VFC Hi-Vol, there are two methods for determining sample volumetric flow rate:

1) using the manufacturer's look-up table, or

2) performing a multiple point (multi-point) calibration.

The manufacturer's look-up table is a matrix describing flow through the VFC at different pressures and temperatures. The volumetric flow rate can be determined from the look-up table by calculating the stagnation pressure ratio (described below) and then using the current temperature to read the corresponding volumetric flow rate from the matrix.

To ensure the accuracy of the manufacturer's look-up table, a three-point (minimum) calibration must be performed on a sampler during the sampler's initial setup. If the calibration curve agrees with the look-up table within ±4%, then subsequent calibrations are not required unless a subsequent audit or flow check suggests an erroneous calibration, the sampler is moved to a different physical location, or major maintenance, such as VFC replacement, is performed.

Following the initial calibration, the operator can use either the look-up table or the multi-point calibration curve to determine sample period volumetric flow rates. Refer to the manufacturer's instructions on how to use a look-up table. A description of a multi-point calibration procedure follows.

A.3.1 Multi-Point Calibration Procedure

A.3.1.1 Apparatus

1) National Institute of Standards and Technology (NIST) traceable variable resistance transfer standard (calibration orifice) with faceplate.

2) Portable thermometer, capable of accurately measuring temperature over the range of 0 to 50 °C to the nearest ±1 °C and referenced to a NIST or American Society for Testing and Materials (ASTM) thermometer within ±2 °C at least annually.

3) Portable barometer, capable of accurately measuring ambient barometric pressure over the range of 500 to 800 millimeters of mercury (mm Hg) to the nearest millimeter of mercury, and referenced within ±5 mm Hg to a barometer of known accuracy at least annually.

4) 0-inch - 16-inch well type manometer with tubing.

5) 0-inch - 36-inch well type manometer with tubing.

6) Calibration Worksheet (Figure A.3.1).

A.3.1.2 Variables

In this section, the following variables are used or derived on the Calibration Worksheet.

1) $\mathbf{Q_a}$(variable) = Volumetric flow rate in actual m^3/min from the calibration curve or look-up table.

2) $\mathbf{\Delta H_2O}$ = Pressure drop, in inches of water, across the calibration orifice.

3) $\mathbf{T_a}$ = Ambient temperature, in Kelvin (K) (K = °C + 273.15).

4) $\mathbf{P_a}$ = Ambient barometric pressure in mm Hg.

5) $\mathbf{\Delta P_{stg}}$ = Relative stagnation port pressure.

6) $\mathbf{P_{rat}}$ = Absolute stagnation pressure ratio.

7) **b** = Intercept of the orifice transfer standard's calibration relationship.

8) **m** = Slope of the orifice transfer standard's calibration relationship.

A.3.1.3 Procedure

1) Open the SSI and, if applicable, remove the filter cassette. Securely install the faceplate adapter on the filter holder and the calibration orifice on the faceplate adapter. Open the calibration orifice for maximum flow.

2) Leak test the calibration orifice and sampler by placing your fingers over the four holes on top of the calibration orifice and one thumb over the manometer nipple on the orifice. Listen carefully for leaks, which are detectable as an audible whistling sound, and troubleshoot if one is heard.

3) Open each manometer's valve and zero the instrument. Connect a section of tubing from the calibration orifice nipple to one 16-inch manometer port. Connect a 36-inch well type manometer to the stagnation port fitting.

SITE LOCATION:
DATE:__________ CALIBRATED BY:
SAMPLER (VFC) NO.:
STANDARD PRESSURE: 760 mm Hg ACTUAL PRESSURE (P_a):
STANDARD TEMPERATURE: 298 K ACTUAL TEMPERATURE (T_a):
Transfer Standard slope (m):
Transfer Standard intercept (b):

$$Q_a(orifice) = \frac{\sqrt{(\Delta H_2O)x(\frac{T_a}{P_a})} - b}{m}$$

Transfer Standard calibration date:

$$X = \frac{Q_a(orifice)}{\sqrt{T_a}}$$

$$Y = P_{rat} = \frac{P_a - \Delta P_{stg}}{P_a}$$

RUN	ΔH_20 in H_2O	STAG mm H_2O	PORT mm Hg	Q_a (orifice)	X-AXIS	Y-AXIS
1.						
2.						
3.						
4.						
5.						

Sampler Slope (m):
Sampler Intercept (b):
Correlation Coefficient (r):

Figure A.3.1 High Volume VFC Calibration Worksheet

4) Complete the top of the Calibration Worksheet including “Site Location,” “Date,” “Calibrated By,” “Sampler (VFC) Number,” “Transfer Standard Slope (m) and Intercept (b),” and “Date of Transfer Standard Certification.”

5) Measure and record the ambient temperature (**T_a**) in Kelvin and the ambient barometric pressure (**P_a**) in millimeters of mercury.

6) Turn on and warm up the sampler until the manometer reading stabilizes.

   a) Read the calibration orifice manometer (**ΔH_2O**) and record the number in the appropriate place on the Calibration Worksheet.

   b) Read the stagnation pressure port manometer (**ΔP_{stg}**) and record the number in the appropriate place on the Calibration Worksheet.

7) Slightly turn the calibration orifice clockwise to restrict the flow through the sampler. Repeat step 6 for at least two more volumetric flow rates. The range of the points should span the acceptable operating range of 1.017 to 1.243 actual m^3/min (±10 percent of 1.130 m^3/min).

8) Return the sampler to operating order.

9) Calculate **Q_a** (orifice) for each data set:

$$Q_a(orifice) = \frac{\sqrt{(\Delta H_2O)x(\frac{T_a}{P_a})} \; - \; b}{m} \qquad \textit{Equation 1}$$

10) Calculate “X” for each data set. Use the widest range of temperatures expected at the monitoring site.

$$X = \frac{Q_a(orifice)}{\sqrt{T_a}} \qquad \textit{Equation 2}$$

11) Calculate **P_{rat}** or "Y" for each data set:

   a) Convert ΔP_{stg} to millimeters of mercury:

$$mm\ Hg = \frac{\Delta P_{stg}\left(in - H_2O\right) x\ 25.4\left(^{mm}/_{in}\right)}{13.61\left(^{in-H_2O}/_{in-Hg}\right)} \qquad \textit{Equation 3}$$

   b) Calculate the absolute stagnation pressure ratio (**P_{rat},** or “Y” axis):

$$Y = P_{rat} = \frac{P_a - \Delta P_{stg}}{P_a} \qquad \textit{Equation 4}$$

12) Using the data in the “X-Axis” and “Y-Axis” columns on the Calibration Worksheet, plot the calibration curve and calculate a least squares linear regression. This curve is used to determine the reported flow in actual cubic meters per minute for each sample run. Complete the Calibration Worksheet for the sampler slope (m), intercept (b), and correlation coefficient (r). A satisfactory calibration should have a minimum "r" value of 0.99.

13) Enter the slope and intercept into the Suspended Particulate Data Entry Form spreadsheet. This spreadsheet should be available at all Idaho DEQ Offices. The equation used by the spreadsheet to calculate sample flows for filters is:

$$Q_{act} = \frac{(P_{rat} - b)\ x\ \sqrt{T_a}}{m} \quad \textit{Equation 5}$$

A.3.2 Single-Point Flow Verification Check

The single point flow check can be done after routine brush changes or motor changes or anytime a quality control flow check is needed. At a minimum, a single point flow verification must be done once quarterly. These can be done by the routine operator or by an independent or agency auditor. Throughout the year, any combination of flow check verifications (by the operator or by an auditor) will suffice as long as one flow rate verification is performed each calendar quarter.

This procedure compares a single measured volumetric flow rate against the volumetric flow rate from the calibration or the look–up table. The single point flow check is identical to a multi-point calibration except the single point flow check procedure measures only a single flow rate taken at or close to the design flow rate of 1.13 actual m^3/min. This is done by installing a filter beneath the faceplate and fully opening the calibration orifice or (without the filter) by adjusting the calibration orifice so the sampler is drawing close to 1.13 actual m^3/min. Refer to the instrument’s operating manual for setup instructions. For the single point flow check, record the parameters listed below, as described in instrument’s operating manual.

1) Ambient pressure and temperature (**P_a and T_a**)

2) Relative stagnation port pressure at a single point near 1.13 m^3/min (**ΔPstg**)

3) Pressure drop of calibration orifice at the same single point as in #2 above near 1.13 m^3/min (**ΔH_2O**)

Following the measurement, calculate the calibration orifice flow rate (**Q_a**[orifice]) and compare it to the calibration or look-up table flow rate and to the design flow rate (1.13 m^3/min):

1) Calculate **Q_a**(orifice) (Equation 1).

2) Find $\mathbf{Q_a}$ (sampler) using Equation 5 or the look-up table flow rate.

3) Calculate and record the percent difference between $\mathbf{Q_a}$ (indicated) and $\mathbf{Q_a}$ (orifice) using Equation 6:

$$\% \ difference = \frac{Q_a(sampler) - Q_a(orifice)}{Q_a(orifice)} \ x \ 100 \quad Equation \ 6$$

Where:

Q_a (sampler) = Indicated volumetric flow rate of the sampler from the calibration curve or the look-up table.

Q_a (orifice) = Actual volumetric flow rate through the calibration orifice.

4) If the percent difference is greater than 7%, recheck the calculations, check the sample train for leaks, and troubleshoot as necessary.

5) Calculate the design flow rate percent difference using Equation 7:

$$\% \ difference = \frac{Q_a(orifice) - 1.13}{1.13} \ x \ 100 \quad Equation \ 7$$

If the design flow rate percent difference is greater than 10%, recheck the calculations and check the sample train for leaks.

A.4 OPERATIONAL PROCEDURES

A.4.1 Office Preparatory Procedure for Filter Changes

1. Remove a clean, unexposed filter from storage. The filters are fragile and should be handled with care. Each filter has been tare weighed, so it is important that the filters remain intact. Use forceps or wear silk, plastic, or latex gloves when handling the filters. If using forceps, be careful not to tear or puncture the filter, and do not touch the filter with the fingers. Inspect the filters closely and discard damaged filters.

2. Record the run date and filter number on the Stagnation Port Field Sheet (Figure A.4.1)

3. Install a new filter on the designated cassette and center the unexposed filter with the *number-side down on the screen*. Attach the filter holder to the cassette screen and tighten the brass-knurled thumbnuts while ensuring the filter remains centered.

4. Record the run date, site name, filter number, and operator's initials on the back of the flow recorder chart and on the envelope.

5. Transport the filter and flow recorder chart to the sampling site.

STAGNATION PORT FIELD SHEET

SITE *LES BOIS* **MONTH** *MARCH* **YEAR** *2002*

RUN DATE	FILTER NUMBER		TEMP (°C)	AMB. PRESS (MM HG)	PSTG. (MM H_2O)	HOBBS (MINS)	COMMENTS
3-3	Q1072570	ON	-0.6	696	450	387397	
		OFF	6.0	691	462	388838	
3-9	Q1072574	ON	6.0	691	462	388838	Brush Change
		OFF	7.0	687	467	390277	
3-15	Q1072576	ON	7.0	687	457	390277	Quarterly Audit (3/11)
		OFF	0.7	688	450	391721	
3-21	Q1072580	ON	0.7	688	455	391721	Quarterly Maint. (3/19)
		OFF	11.7	685	470	393160	
3-27	Q1072582	ON	11.7	685	457	393160	
		OFF	18.1	684	480	394598	

Figure A.4.1 Stagnation Port Field Sheet

A.4.2 Field Procedure

1) Essential Equipment

   a. 36-inch manometer

   b. On-site or portable thermometer

   c. On-site or portable barometer

2) Filter Setup for Initial Run

   a. Unfasten the hold-down clips at the base of the SSI and tilt back the inlet until the supporting arm locks in place.

   b. Remove the protective cover and install the prepared cassette. Secure the hold-down nuts firmly, but do not over-tighten.

   c. Unlock the supporting arm, lower the SSI, and secure the inlet with the base clips.

   d. Insert the new flow recorder chart into the flow recorder. Center the tab on the slotted drive. Ensure that the chart will rotate 360° without binding or slipping.

   e. Read the elapsed time indicator and record on the Stagnation Port Field Sheet.

   f. Open the manometer's valves to the atmosphere and plug the manometer into the stagnation port on the right-hand side of the monitor. Zero the manometer fluid using the sliding scale. The manometer is usually read at the bottom of the meniscus.

   g. Start the sampler by tripping the timer switch to the "on" position. Allow the motor to warm up until the manometer reading is steady (approximately 3 to 5 minutes). Record the manometer reading in the "Pstg" column in the "On" row on the Stagnation Port Field Sheet.

   h. If an on-site pressure and/or temperature recorder is being used, reset or reinstall the chart paper as necessary (depending on type of recorder).

NOTE: For each sample period, use the 24-hour pressure and temperature values for the midnight-to-midnight sampling period. Ideally, temperature and pressure from a National Weather Service (NWS) site or local meteorological site should be used. Use the pressure at the station and *not* the pressure adjusted to sea level. When these data are not available, the pressure can be estimated based on elevation using Equation 8:

$$P_{est}(mmHg) = 753.56 - (elevation(ft) * 0.02425) \quad Equation\ 8$$

A single pressure estimate can be used since pressure fluctuation over time is insignificant. Temperature is more critical because of unpredictable fluctuations. If nearby temperature data is not available, it is recommended that an on-site temperature recorder be installed. Seven-day chart recorders are available.

i. Turn the sampler off.

j. Check the timer clock to ensure that the indicator arrow accurately points to the current standard time. It should not deviate from the current time by more than 30 minutes.

k. By turning the dial clockwise, set the timer clock to start the sampler at the predetermined start time of 0000 hours (midnight) on the designated sample date, and to shut off at 2400 hours (midnight) (±30 minutes).

   i) The on and off timer pins should represent a 24-hour 00 minute time period, midnight-to-midnight, local standard time. Once set, these pins should require no additional adjustments.

   ii) When setting the timer to start the sampler on the run date, count (from the current calendar day) the calendar days counterclockwise from the indicator arrow on the timer face to the period indicated between the timer pins. If the timer is set properly, the period between the timer pins should be the run date.

l. Close the shelter door and ensure the tubing for the flow recorder chart and the electrical cords are not pinched.

m. If the manometer is permanently secured at the monitor site, disconnect the manometer from the monitor stagnation port and close the manometer valves to prevent dirt, water, and microbes from entering the manometer tube.

3) Filter Setup for Subsequent Runs

   a. When approaching the monitor, observe that the unit is reasonably undisturbed (e.g., from wind storms, vandalism, or other disturbances) since the last site visit. Report any abnormalities in the “Comments” section on the stagnation port field sheet.

   b. Start the sampler by tripping the timer switch to the "on" position. Allow the motor to warm up approximately 3 to 5 minutes.

   c. While the sampler is warming up, open the manometer valves and zero the manometer fluid using the sliding scale. Plug the manometer into the stagnation port on the right-hand side of the monitor. On the Stagnation Port Field Sheet, record the manometer fluid level in the “Pstg” column in the “Off” row.

d. If an on-site pressure and/or temperature recorder is being used, reset or reinstall the chart paper as necessary (depending on type of recorder).

NOTE: For each sample period, use the 24-hour pressure and temperature values for the midnight-to-midnight sampling period. Ideally, temperature and pressure from a NWS site or local meteorological site should be used. Use the pressure at the station and *not* the pressure adjusted to sea level. When these data are not available, the pressure can be estimated based on elevation using Equation 8.

A single pressure estimate can be used since pressure fluctuation over time is insignificant.

Temperature is more critical because of unpredictable fluctuations. If nearby temperature data is not available, for example at a remote site, it is recommended that an on-site temperature recorder is installed. Seven-day chart recorders are available.

e. Turn the timer switch to the "off" position. Record the elapsed time meter reading in the appropriate column on the Stagnation Port Field Sheet.

f. Ensure the flow recorder is operating properly. Record the monitor location, run date, filter number, and operator's initials on a new chart. Remove the used flow recorder chart and insert the new chart. Be sure that the chart will be able to rotate the full 360° without binding or slipping.

   i) Perform a quality control check of the used flow recorder chart by observing the chart trace for uniformity, consistency, and duration. Radial lines indicate power interruption or power failure.

   ii) Note any pertinent comments or anomalies on the Stagnation Port Field Sheet.

g. Unfasten the hold-down clips at the base of the SSI and tilt back the inlet until the supporting arm locks in place.

h. Observe the filter for any damage or unusual deposition.

i. Loosen the hold-down nuts from the cassette. Cover the exposed filter with the cassette protective cover and remove the cassette. Store the filter cassette with the exposed filter in a protected area for transport to the office. The exposed filter should be handled and transported horizontally to minimize particulate loss.

j. Install the previously prepared cassette.

k. Unlock the supporting arm, lower the SSI, and fasten the base clips.

l. Start the sampler by tripping the timer switch to the "on" position.

m. Read the manometer fluid level and record it in the "P_{stg}" column in the "On" row on the Stagnation Port Field Sheet.

n. Turn the timer switch to the "off" position.

o. Check the timer to ascertain that the indicator arrow points to current local time of day. This should always reflect standard time, so the clock will actually be set one hour early during daylight savings time.

p. By turning the dial clockwise, set the timer clock to start the sampler at the predetermined start time of 0000 hours (midnight) on the designated date, and to shut off at 2400 hours (midnight) (±30 minutes).

   i) Timer pins should represent a 24-hour time period, midnight-to-midnight. Once set, these pins should require no additional adjustments.

   ii) When setting the timer to start the sampler on the run date (from the current calendar day), count the calendar days counterclockwise from the indicator arrow on the timer face to the period indicated between the timer pins. If the timer is set properly, the period between the timer pins should be the run date.

q. Close the shelter door and ensure the flow recorder chart tubing and electrical cords are not pinched.

r. Fill out the Stagnation Port Field Sheet completely and accurately each month. Include references to weather conditions and any unusual activities that might increase or decrease the normal fine particulate loading level (for example, building construction, excavation, forest fires, high winds, etc.).

A.5 PM_{10} FILTER HANDLING AND REPORTING PROCEDURES

A.5.1 Exposed Filter Handling

1) Remove the filter from the cassette. Wear plastic, silk, or latex gloves at all times when handling the filters.

2) Inspect the filter for damage, including tears and blurred or fuzzy borders. An acceptable filter must have a uniform sharp white border. Dark streaks into the border indicate a poor seal of the filter holder gasket.

3) Carefully remove insects and/or any obviously large debris from the filter.

4) Length-wise, fold the filter in half ***with the exposed side inward***.

5) Place the filter in a plastic envelope and insert it in a manila envelope. The location, operator's initials, and run date should already be recorded on the manila envelope (do this before leaving the office). Record any relevant comments on the envelope, such as, "VOIDED FILTER--MOTOR FAILURE." Be certain the exposed filter number corresponds to the matching number on the manila envelope.

6) Insert the appropriate flow recorder chart into the corresponding manila envelope.

7) Store envelopes containing exposed filters in a freezer until they are submitted to the laboratory.

A.5.2 Exposed Filter Data Reporting

1) Submit exposed filters to the laboratory monthly. The filters must be mailed in a monthly batch no later than the fifteenth of the month following the month when they were collected. Group the filters by site, and fill out a Lab Particulate Data Report (Figure A.5.1) for each site. Record the site name, the site Air Quality System number, the month and year of collection, the date the filters were sent to the laboratory, the filter numbers with the associated sampling date, and any necessary comments on the form.

2) Verify that the filter and flow recorder chart are in the appropriate numbered manila envelope, that the data on the envelope is the same as the data on the Stagnation Port Field Sheet (Figure A.4.1), and that any comments are recorded on the envelope and the Lab Particulate Data Report.

3) Send the filters and the corresponding Lab Particulate Data Reports to:
   Bureau of Laboratories
   2220 Old Penitentiary Road
   Boise, Idaho 83712

4) After the exposed filters have been final weighed, the laboratory will return the Lab Particulate Data Report with the net weight of the particulate. DEQ State Office personnel pick up the filters monthly for archiving and quality assurance/quality control purposes.

5) Upon receipt of the Lab Particulate Data Reports with the net weights, use the information recorded on the Stagnation Port Field Sheet and the Lab Particulate Data Report to enter the required data into the Suspended Particulate Data Entry Form spreadsheet. The required information to be entered on a monthly basis is highlighted in the Suspended Particulate Data Entry Form spreadsheet. Other information, such as the calibration slope and intercept, only need to be re-entered when the conditions change. Password-protect the cells containing relatively stable data to prevent accidental changes. Upon entering the information into the spreadsheet, the spreadsheet will generate the final concentration at both standard and actual conditions for each sample.

6) Send hard copies of the worksheets listed below to the State Office within six weeks of the end of the relevant month for the final quality assurance check. The State Office will submit the data into the Air Quality System database within 90 days after the quarter in which the samples were collected.

- Lab Particulate Data Report
- Suspended Particulate Data Entry Form
- Stagnation Port Field Sheet
- Meteorology report (if applicable)

7) Following the laboratory's final mass analysis of the filters, check the final Lab Particulate Data Repor*t* to ensure it is complete and accurate.

LAB PARTICULATE DATA REPORT				
0			**LAB # 84-85340E96-000-5009**	
STATION NAME:	**Boise Mt View School**	SENT TO LAB:	0	
STATION #	160010011	RECEIVED BY LAB:		
MONTH	**July**	REPORT BY LAB:		
YEAR	**2002**			
Filter Number	**Date July**	**Net Weight (mg) Particulate**	**Lead**	**Comments**
Q2003796	1			
Q2003798	7			
Q2003800	13			
Q20037802	19			
Q2003804	25			
Q2003806	31			
0	0			
0	0			
		LAB OPERATOR		

Figure A.5.1 Lab Particulate Data Report

SITE _____________ MONTH ___________ YEAR ____ AQS #

RUN DATE	FILTER NUMBER		TEMP. (°C)	AMB. PRESS. (mm Hg)	PSTG. (mm H_2O)	HOBBS (MINS)	COMMENTS & TECH INITIALS
		ON					
		OFF					
		ON					
		OFF					
		ON					
		OFF					
		ON					
		OFF					
		ON					
		OFF					
		ON					
		OFF					

Figure A.5.2 Stagnation Port Field Sheet

A.6 PREVENTATIVE MAINTENANCE

Preventative maintenance is accomplished by properly following the normal operating procedures outlined in this section and in manufacturer's manual. All preventative maintenance activities should be recorded on the Stagnation Port Field Sheet, the Calibration Worksheet, or in the site logbook. Records should be kept on (but are not limited to) the following:

1) Leaks
2) Tubing replacement
3) Plug and wiring alterations
4) Clock accuracy checks
5) Flow recorder chart adjustment or replacements
6) Sampler housekeeping
7) Audit percent differences and dates
8) Calibration/recalibration
9) Motor and/or brush replacement
10) Anything else deemed necessary or helpful to the site operator

The following service checks will be performed according to the procedures described in this section. Checks may be performed more frequently, but must be performed at least at the prescribed intervals. Major maintenance activities (i.e., sampler brush change, motor replacement, housing changes, etc.) will require a single point calibration check upon completion.

A.6.1 Quarterly/Semi-Annual Checks

All maintenance checks must be recorded in the site logbook. A single point flow rate verification must be done quarterly. This can be done by the operator or an auditor, or any combination thereof, as long as one check is done each calendar quarter.

Under normal operating conditions, the SSI should be completely disassembled and cleaned, and the impaction shim re-coated after 60 full 24-hour sampling periods, or every six months, whichever is sooner. It is highly recommended that samplers located at sites experiencing abnormally high concentrations of particulates be cleaned after 30 sampling periods (or every three months) to prevent particle bounce-off. Follow the steps listed below:

1) Make sure the tubing is properly connected to both the flow recorder and the motor housing pressure tap. Also, inspect tubing for creases, cracks, and loose connections.

2) Inspect the large threaded locking collar located between the filter holder and the top of the volumetric flow controller for looseness, and tighten if necessary.

3) Separate the SSI in the middle and open it to inspect the cleanliness and position of the silicon coated impaction plate. If dirty, clean the plate with soapy water, dry thoroughly, apply an even application of silicon to the impaction plate, and reinstall with silicon greased side up. Clean as often as necessary to prevent particle “bounce off.”

4) Inspect the motor brushes. Allowing the brushes to wear down completely causes electrical arcing, which will permanently damage the commutator. It is recommended that the brushes be changed every 336 hours (14 consecutive 24-hour runs) of operation. It may be necessary to change less or more frequently, depending upon ambient particulate concentrations and motor condition. Seat the motor brushes according to the manufacturer’s instructions.

5) During the brush inspection, inspect the commutator. Once the commutator becomes worn, the brush life is reduced significantly. Replace the motor if the commutator shows excessive wear (more than 0.125 inch total), deep grooving, or lack of segmentation.

6) Inspect the motor when replacing the brushes. Pull at the center motor shaft to check for excessive in-play. If shaft in-play exceeds 0.0625 inches (1/16 inch) in any one direction, replace the motor.

7) Inspect the motor wiring for abnormalities (e.g., burned, or scorched wires).

8) Inspect the top and bottom rubber motor gaskets for wear or deterioration. Replace the gaskets if necessary. Twisted power leads may indicate that motor gaskets are not holding the motor firmly. This also indicates that the gaskets may need to be replaced.

9) Inspect the gasket between the filter holder and the critical orifice volumetric flow controller, and replace if necessary.

10) Inspect the gasket between the filter holder and the sampler head base plate, and replace if necessary.

11) Check the motor housing for cracks, and replace if necessary.

12) Check the power cord to the motor housing and replace if deteriorated.

A.6.2 Annual Checks

Inspect the elapsed time indicator when installing the sampler for proper operation. Compare this elapsed time indicator annually against a standard timepiece, of known accuracy, recently set to the appropriate time zone. Official time should be synchronized with the NIST and United States Naval Observatory clock, found at www.time.gov. If they do not agree within ±2 minutes per 24 hours, replace the unit.

A.6.3 Spare Parts

Part of preventative maintenance is keeping an on-hand spare parts supply. The following is a suggested list for PM_{10} sampler supplies. The number and amount of supplies will vary depending on the size of the network.

- Motor housing and end plates
- Flow chart recorders
- Timers
- Elapsed time meters
- Filter cassettes
- Motors
- Brushes
- Thick motor gaskets
- Motor end plate gaskets
- Filter holder gaskets
- Flow chart paper
- Pigtail (motor housing)

- SSI gaskets (set)
- Silicon spray
- Pens
- Barometers
- Thermometers
- 36-inch manometers

A.7 TROUBLESHOOTING

When the monitor becomes inoperable for an unknown reason, the site operator may have to troubleshoot to determine the cause of the failure. Below is a partial list of solutions for two of the most common problems encountered when operating PM_{10} samplers.

<u>Symptom</u>: Unit does not power up.

<u>Check</u>:

1) Power cords. Are they plugged in?
2) Brushes (disassemble motor)
3) Breaker and/or fuses on power supply.
4) Wires. Are all wires from the motor connected properly?
5) Timer. Is it wired properly? Worn? Check by bypassing timer.

<u>Symptom</u>: Unit functions, but flow trace is uneven, or flow trace is higher/lower than previous runs.

<u>Check</u>:

1) Tubing between the motor and flow recorder; Look for cracks, leaks, etc. and look to see if pinched or cracked.
2) Motor housing; Look for cracks, leaks, etc.
3) Flow recorder pen; Is it secured in place or loose?
4) Filter; Has it been exposed to weather and become wet, or otherwise inadvertently soiled? Have two been loaded?
5) Sample train; Are there restrictions in it?
6) VFC throat adapter connection.

<u>NOTE</u>: Daily line voltage fluctuations can cause an uneven trace. If the monitor is located on a building and sharing power with heating or air conditioning units, equipment cycling will cause fluctuations in the line voltage.

A.8 SPECIAL PROJECT MONITORING

Special project monitoring will be conducted under the guidance in this document or otherwise as reviewed and approved on a case-by-case basis. Special projects may require more stringent procedures depending upon the purpose of the data and the scope of the project. Specific written procedures or methodologies for the operation of PM_{10} monitors or for data handling must be adhered to by all those individuals, firms, or agencies that are producing air quality data for enforcement purposes or under the terms of an air quality permit.

APPENDIX B

PM$_{2.5}$ RUPPRECHT & PATASHNICK PARTISOL® – FEDERAL REFERENCE METHOD MODEL 2000 SAMPLER

STATE OF IDAHO

DEPARTMENT OF ENVIRONMENTAL QUALITY

AIR MONITORING QUALITY ASSURANCE

STANDARD OPERATING PROCEDURES

FOR

AIR QUALITY MONITORING

MONITORING, MODELING, AND EMISSIONS INVENTORY

APRIL 2001

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Acronyms, Units, And Chemical Nomenclature

AQS	Air Quality System
EPA	Environmental Protection Agency
FRM	Federal Reference Method
IBL	Idaho Bureau of Laboratories
LCD	Liquid Crystal Display
lpm	Liters per minute
m	Meters
mm	Millimeters (10^{-3} m)
mm Hg	Millimeters of mercury
µm	Micrometers (10^{-6} m)
µg/m^3	Micrograms per cubic meter
NAAQS	National Ambient Air Quality Standards
NIST	National Institute of Standards and Technology
PM$_{2.5}$	Particulate Matter with a Mean Aerodynamic Diameter of 2.5 µg or less
PM$_{10}$	Particulate Matter with a Mean Aerodynamic Diameter of 10 µg or less
QA	Quality Assurance
SOP	Standard Operating Procedure
VDC	Volts Direct Current

B.1 GENERAL INFORMATION

The federal reference method for the measurement of PM$_{2.5}$ (particulate matter with a mean aerodynamic diameter of 2.5 micrometers [µm] or less) is presented in 40 CFR Part 50, Appendix L. Sampler siting, operation, and quality assurance (QA) regulations are presented in 40 CFR Part 58. The operating procedures presented in this standard operating procedure (SOP) are derived from the cited regulations and the guidance presented in the manufacturer's instructions and the U.S. Environmental Protection Agency's (EPA) *Quality Assurance Handbook for Air Pollution Measurement Systems,* Section 2.12.

B1.1 Specifications

STANDARDS:	State:	Federal standards adopted by Idaho
	Federal:	Primary 65 µg/m^3, 24 (±1 hour) hour block arithmetic mean (midnight-midnight local standard time) 15 µg/m^3 annual arithmetic mean concentration
METHOD:		Rupprecht & Patashnick Partisol-FRM with PM$_{10}$ size-selective inlet and WINS PM$_{2.5}$ impactor
FLOW CONTROL TYPE:		Microprocessor-based volumetric flow control
FLOW RANGE:		1 m^3/hr (16.7 lpm) (±10%)
FILTER MEDIUM:		Teflon® – 47 mm
MANUFACTURER:		Rupprecht & Patashnick

B.1.2 Principles of Operation

A system flow schematic for the Rupprecht & Patashnick Partisol-Federal Reference Method (FRM) is presented in Figure B.1.1. Ambient air is drawn into the sampler through the size-selective PM$_{10}$ (particulate matter with a mean aerodynamic diameter of 10 µm or less) inlet at a constant volumetric flow rate of 16.7 liters per minute (lpm). The PM$_{10}$ inlet provides a nominal cut-point of approximately 10 µm, allowing only particles less than 10 µm to pass into the down-tube. The ambient air enters the Wedding and Associate Inertial Separator (WINS) impactor that provides a nominal cut-point of 2.5 µm, allowing only particles less than 2.5 µm to pass onto the 47 millimeter (mm) Teflon® filter.

The flow rate through the sampler is maintained by a mass flow controller coupled to a microprocessor and ambient temperature and pressure sensors to provide a constant volumetric flow rate. The microprocessor reads, averages, and stores five-minute averages of ambient temperature, ambient pressure, filter temperature, and volumetric flow rate. In addition, the microprocessor calculates the average temperature and pressure, total volumetric flow for the entire sample run time, and the coefficient of variation of the flow rate.

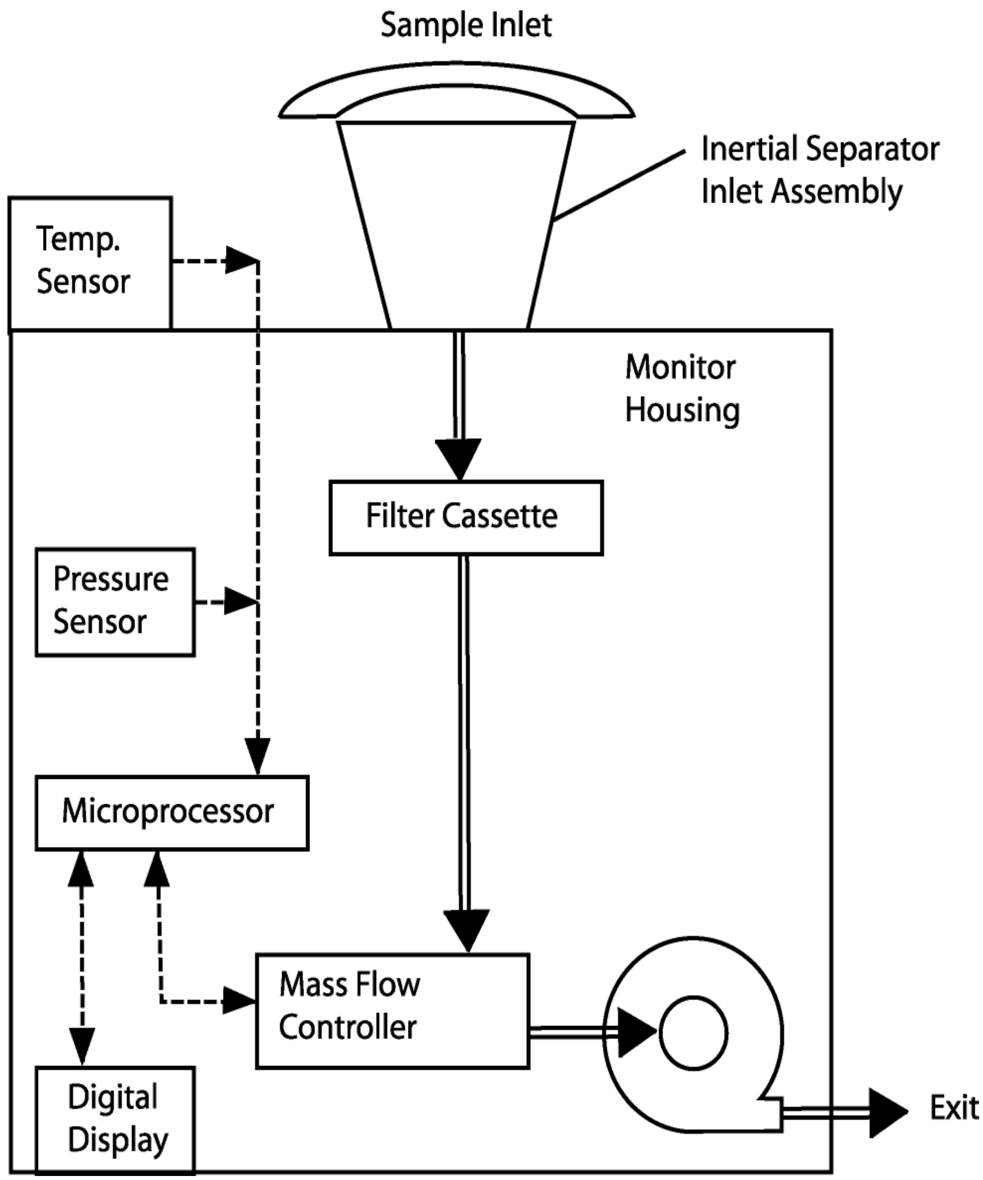

Figure B.1.1 Rupprecht & Patashnick Partisol – Federal Reference Method System Flow Schematic

B.2 PARTISOL-FRM DISPLAY SCREENS

The Partisol-FRM employs a liquid-crystal display (LCD) screen with a menu system to activate sampler functions, program the sampler for operation, and view stored data. The brightness of the screen can be adjusted with the black knob below and to the left of the keypad. If no keys have been pressed for a prolonged period of time, the screen powers down to save energy. To restore the screen, press any key.

Upon initial power-up, the sampler displays the Title Screen that shows the manufacturer, model number, and software version. In addition, this screen allows access to three functions for resetting hardware configurations to factory defaults. This screen is shown only momentarily, after which the Main Screen is displayed.

Each screen is named. The name of the screen appears in the middle of the top line of the screen. On the left of this row is the sampler status code. On the right side is the current operating mode. The bottom row of each screen lists the functions associated with the function keys F1 → F5. Not all screens have a function associated with each function key.

The Primary Screen shows the main menu. Other screens can be accessed by pressing the appropriate function key. To return to the previous screen, press the Esc key.

Further descriptions of the operating software and menu system are presented in Section 4 of the operating manual.

B.3 INSTALLATION

B.3.1 Siting Requirements

Samplers should be sited to meet the goals of the specific monitoring project. For routine sampling to determine compliance with the National Ambient Air Quality Standards (NAAQS), sampler siting is regulated by 40 CFR Part 58 and described in *State of Idaho PM$_{2.5}$ Monitoring Network Description* and *Quality Assurance Project Plan for the State of Idaho PM$_{2.5}$ Ambient Air Quality Monitoring Program*.

B.3.2 Sampler Locations

Samplers should be mounted on a safe, suitable monitoring platform according to the following guidelines:

- The PM$_{2.5}$ sampler must be exposed to unobstructed airflow in all directions for a minimum of 2 meters (m) horizontal distance.
- The sampler inlet must be placed between 2 and 15 m above ground level.

- If a sampler is collocated with other samplers, the minimum spacing between sampler inlets is as follows:

  - If collocated with other PM$_{2.5}$ or other low-volume samplers (flow rate < 16.7 lpm) maintain a minimum distance between sampler inlets of 1 m.

  - If collocated with total suspended particulate samplers or other high-volume samplers (flow > 16.7 lpm), maintain a minimum distance between sampler inlets of 2 m.

B.3.3 Sampler Setup

Prior to first use, set up the sampler following the instructions provided in Section 2.2 of the manufacturer's operating manual and as follows:

1) Inspect the sampler to ensure that all transport restraints and tie wraps are removed from the sampler enclosure.

2) Install the one large and two small rain hoods over the appropriate openings in the sampler enclosure. Be sure to install the rubber gaskets on the rain hoods prior to installation.

3) Insert the sample tube. The sample tube typically has two machined ends. On one end the machining extends 2 inches from the end. On the other end, the machining extends 1.25 inches. Insert the end of the sample tube with the 2-inch machined section into the top of the bulkhead fitting on the top of the sampler enclosure. Firmly push the tube into the fitting, through the final O-ring until it stops. Gently tighten the nut on the bulkhead fitting.

4) Insert the PM$_{10}$ sampling head onto the top of the sampling tube. Firmly push the sampling head onto the tube, past the inlet's two O-rings until it stops.

5) Attach the ambient temperature sensor assembly (temperature probe and radiation shield) to the two holes provided toward the top of the left side of the enclosure. Install the unit so that the temperature probe extends up and to the left of the enclosure. If the unit was supplied with washers, place the washers between the temperature assembly and the enclosure, not under the head of the screws. This ensures a watertight assembly. If the unit did not come with washers, install the assembly with screws only.

6) Connect the ambient temperature cable to the connector on the back of the enclosure labeled "Temperature Sensor."

7) Prepare the Wedding and Associates Inertial Separator (WINS) PM$_{2.5}$ impactor for use following the procedures described in Appendix H: Maintenance of Inlets, in the *Partisol-FRM Model 2000 PM$_{2.5}$ Air Sampler Operating Manual*,

8) Connect the sampler to a safe, reliable power source.

9) Follow the procedures in Section B.3.4 to setup the system software.

10) Conduct a sampler external and internal leak check.

11) Perform a temperature calibration, a pressure calibration, and a multi-point flow calibration.

12) Prepare the sampler for sample collection following the procedures in Section B.7.

B.3.4 Sampler Software Setup

Prior to first use, the sampler software needs to be reset and default values need to be entered. The following procedures should be followed:

1) If not already off, turn the sampler off using the power switch on the front panel.

(The following step will perform a complete hardware and software reset of the sampler. All calibration constants for temperature, pressure and flow will be lost and the sampler will have to be recalibrated. Only perform these steps upon initial installation or when a major system reset is necessary.)

2) Turn the sampler power on. While the Title Screen is displayed, press the F3 key twice. The sampler will make three beeps after the Title Screen disappears to indicate that the sampler hardware and software have been reset.

3) From the Main Screen, press F5 to access the Setup Screen.

4) From the Setup Screen, press F1 to enter the edit mode.

5) Using the arrow keys, position the cursor on the “Def Start” field. Using the keypad, enter the default start time for sample runs (for routine NAAQS monitoring, enter 00.00 for midnight). Do not press Enter.

6) Use the arrow keys to move to the “Def Dur” field. From the keypad, enter the default sampling duration in hours and minutes (for routine NAAQS monitoring, enter 024.00). Do not press Enter.

7) If the “Set Flow” field does not show 16.7 lpm, move the cursor to the “Set Flow field” and enter 16.7 from the keypad. Do not press Enter.

8) Using the arrow keys, position the cursor on the “Cur Time” field. Using the keypad, enter the current time in 24-hour time (e.g., 1:00 pm is 13.00). Press Enter. The clock is now set and the sampling time defaults have been entered.

9) From the Setup Screen, press F4 to access the RS-232 Setup Screen. Verify that the settings are as listed below or as needed to match the values set in the AKCOMM software on the computer that will access the sampler.

Baud: 9600	AK Station: 52
Config: 8-N-1	AK Channel: 75048
Xon/Xoff Cont: ON	AK Append: 13010

10) If the values do not match the above, press the F1 key to enter the edit mode. Use the arrow keys to move to the correct field. Enter the correct value from the keypad and press Enter.

11) Return to the Main Screen by pressing Esc twice.

12) From the Main Screen, press F1 to access the Filter Setup Screen.

13) Press F1 to enter the edit mode.

14) Use the arrow keys to move the cursor to the “ID1” field.

15) Using the keypad, enter the unique Air Quality System (AQS) code and sampler identification number that will identify all samples collected by this sampler and press Enter.

16) Perform all necessary sampler calibrations.

B.4 LEAK CHECK PROCEDURES

Leak checks are critical for maintaining the equipment in optimum operating condition. These checks are just one step in assuring that the particulate concentrations obtained are representative of the actual conditions in the sampler’s monitoring area.

B.4.1 External Leak Check Procedure

Upon initial installation of the sampler, following sampler repair or maintenance, and at least once every five sample days, perform a sampler external leak check according to the following procedure:

1) Perform any required sample recovery from the previous sample run, if necessary.

2) Ensure that the sampler is in the STOP mode by pressing the F4 key in the Main Screen.

3) Install a filter cassette containing a Teflon® filter (designated for calibrations/leak checks) in the filter holder. Do not use a filter that is to be used for sampling.

4) Carefully lift straight up on the PM_{10} inlet to remove it from the sampling tube.

5) Install the supplied flow audit adapter onto the end of the sampling tube.

6) Open the valve on the flow audit adapter (valve fins vertical).

7) From the Main Screen, press F5 to access the Setup Screen.

8) From the Setup Screen, press F5 to access the Audit Screen.

9) Turn on the pump by pressing the F3 key.

10) Turn on the flow valve by pressing the F2 key.

11) Shut the valve on the flow audit adapter (valve fins horizontal).

12) Open the pump access door on the lower half of the sampler. Inside are a vacuum gauge and two valves (one to the left of the gauge and one below the gauge).

13) Shut off the flow to the flow controller by shutting the valve to the left of the vacuum gauge (valve fins perpendicular to the tubing).

14) Allow the vacuum gauge to stabilize. The measured vacuum should register at least 15 millimeters of mercury (mm Hg).

15) Shut off the flow to the pump by shutting the valve below the vacuum gauge (valve fins perpendicular to the tubing).

16) Turn off the pump by pressing the F3 key.

17) Read and record the vacuum gauge reading.

18) Wait 30 seconds and record the vacuum gauge reading. The reading should not have dropped by more than 8.5 mm Hg during this 30-second period (corresponds to a leak rate of 80 milliliters per minute). If the decrease in vacuum is greater than 8.5 mm Hg, initiate corrective action to locate and repair the leak.

19) Open the flow controller valve and pump valve (left and below the vacuum gauge).

20) Open the flow audit adapter valve and remove the adapter from the sampler.

21) Reinstall the PM_{10} inlet.

B.4.2 Internal Leak Check Procedure

Upon initial installation of the sampler, following sampler repair or maintenance, and at least once every five sample days, perform a sampler internal leak check according to the following procedure:

1) Perform any required sample recovery from a previous sample run, if necessary.

2) Ensure that the sampler is in the STOP mode by pressing the F4 key in the Main Screen.

3) Using a filter cassette containing a Teflon® filter (designated for calibrations/leak checks), carefully separate the filter cassette and place the impermeable leak check disk over the Teflon® filter. Reassemble the filter cassette. Place this filter cassette in the filter holder.

4) Carefully lift straight up on the PM$_{10}$ inlet to remove it from the sampling tube.

5) Install the supplied flow audit adapter onto the end of the sampling tube.

6) Open the valve on the flow audit adapter (valve fins vertical).

7) From the Main Screen, press F5 to access the Setup Screen.

8) From the Setup Screen, press F5 to access the Audit Screen.

9) Turn on the pump by pressing the F3 key.

10) Turn on the flow valve by pressing the F2 key.

11) Shut off the flow to the flow controller assembly by turning the manual shut-off valve (flow control manual valve) attached to the large air filter on the left side of the manifold in the hub. Record the reading on the vacuum gauge.

12) Shut off the flow to the pump by turning the other manual shut-off valve (pump manual valve) located on the bottom of the manifold in the hub.

13) Wait 30 seconds, then record the reading on the vacuum gauge. If the reading dropped less than 8.5 mm Hg from the initial reading, the sampler has passed the leak check. If the pressure dropped more than 8.5 mm Hg, take corrective action to locate and repair the leak.

14) Turn off the flow valve by pressing the F2 key.

15) Turn off the pump by pressing the F3 key.

16) Open the flow audit adapter valve and remove the adapter from the sampler.

17) Reinstall the PM$_{10}$ inlet.

18) Remove the leak check disk from the filter cassette.

B.5 TEMPERATURE VERIFICATION PROCEDURES

B.5.1 Single-Point Temperature Verification Check

A single-point temperature verification check of the ambient temperature sensor and the filter temperature sensor must be performed at least once every four weeks on each Partisol-FRM sampler. The temperature check is performed as follows:

1) Perform any required sample recovery from a previous sample run, if necessary.

2) Ensure that the sampler is in the STOP mode by pressing the F4 key in the Main Screen.

3) From the Main Screen, press F5 to access the Setup Screen.

4) From the Setup Screen, press F5 to access the Audit Screen.

5) Place the temperature transfer standard in proximity to the ambient temperature sensor. Be sure that both sensors are shaded from direct sunlight.

6) Read the temperature transfer standard reading and the ambient temperature reading (from the sampler display) and record these values on the PM$_{2.5}$ Sampler Single-Point Calibration Verification Worksheet, Figure B.5.1.

PM$_{2.5}$ Sampler Single-Point Calibration Verification

Date:__________ Time:__________ Site ID:__________ Site Name:__________

Sampler Model:__________ Sampler Serial Number:__________

Leak Checks:

External			Internal	
Time	Indicated Pressure, In. Hg		Time	Indicated Pressure, In. Hg

❑ Pass External Check, check if pressure drop is less than 5 inches Hg after 60 seconds
❑ Pass Internal Check, check if pressure drop is less than 3.5 inches Hg after 30 seconds

Single Point Sampler Calibration Verification Checks:

Transfer Standard Information					
Parameter	Type	Serial Number	Slope	Intercept	Certification Date
Temperature					
Pressure					
Flow Rate					

Field Data					
Parameter	Transfer Standard Readings Corrected	Uncorrected	Sampler Readings	Difference (Sampler-Transfer)	% Difference (Diff/TS x 100)
Filter Temp, °C					
Ambient Temp, °C					
Pressure (mm Hg)					
Flow (L/min)					

Maintenance Performed:

❑ Inspect PM$_{10}$ Inlet O-rings (qtrly)
❑ Inspect Bulkhead O-rings (qtrly)
❑ Inspect Tubing/fittings (qtrly)
❑ Change In-line Filter (6 months)
❑ Inspect Lip Seals (each run)
❑ Clean Air Screens (6 months)
❑ Empty Water Jar (5 sample days)
❑ Clean WINS Impactor (5 sample days)
❑ Clean WINS Impactor Jets (monthly)
❑ Check Battery Voltage (6 months)
❑ Check Sampler Clock (monthly)
❑ Clean PM$_{10}$ Inlet (14 samples)
❑ Clean Sample Tube (qtrly)
❑ Inspect WINS O-rings (qtrly)

Figure B.5.1 PM$_{2.5}$ Sampler Single-Point Calibration Verification Worksheet

7) Calculate the difference between the temperature readings. If the ambient temperature is within ±4 °C of the temperature transfer standard, the sampler's temperature is verified. If the temperature difference exceeds ±4 °C, conduct a temperature calibration followed by a multi-point temperature verification.

8) Repeat steps 5-7 above for the filter temperature sensor.

B.5.2 Multi-Point Temperature Verification Check

Multi-point temperature verification checks must be conducted upon initial sampler installation and at least once per year thereafter. The multi-point temperature verification should also be conducted following a temperature calibration or when a single-point temperature verification check indicates a temperature difference greater than ±4 °C. To conduct a multi-point temperature verification check:

1) Perform any required sample recovery from a previous sample run, if necessary.

2) Ensure that the sampler is in the STOP mode by pressing the F4 key in the Main Screen.

3) Prepare three stable thermal masses of 0 °C, ambient temperature, and approximately 40 °C. The low temperature thermal mass is prepared by mixing water with crushed ice to form a slurry in an insulated thermos bottle. The ambient and hot temperature thermal masses are prepared by placing ambient temperature or hot (40 °C) water in an insulted thermos bottle.

4) From the Main Screen, press F5 to access the Setup Screen.

5) From the Setup Screen, press F5 to access the Audit Screen.

6) Remove the ambient temperature sensor from its radiation shield by loosening the two screws located at the bottom of the shield and sliding the sensor out of the shield.

7) Remove the filter temperature sensor from the lower half of the filter holder. This is accomplished by loosening the retaining nut on the bulkhead fitting and sliding the temperature sensor out of the filter holder. Pull enough slack in the filter temperature sensor wire to be able to locate the filter temperature sensor out of the sampler door.

8) Using two rubber bands, wrap the ambient temperature sensor, the filter temperature sensor, and the temperature transfer standard together with the sensor tips next to one another.

9) Immerse the temperature sensors in the ambient temperature bath and stir the bath. Continue stirring the bath until the readings on the temperature sensors have stabilized.

10) Read the temperature transfer standard reading, the filter temperature reading (from the sampler display), and the ambient temperature reading (from the sampler display) and record these values in the site logbook.

11) Remove the temperature sensors from the ambient temperature bath.

12) Repeat steps 9 – 11 above for each thermal mass in the order of AMBIENT – COLD – AMBIENT – HOT – AMBIENT until three readings have been obtained for each temperature range (cold, ambient, hot).

13) For each set of temperature readings:

    a. Calculate the difference between the temperature transfer standard readings and both the ambient temperature reading and the filter temperature reading.

    b. For each temperature range (cold, ambient, hot), calculate the average temperature difference for the five readings.

14) If any of the average temperature differences exceed ±2 °C calibrate the appropriate temperature sensor (ambient or filter), or initiate corrective action to repair the sensor and/or sampler. If all of the average temperature differences are less than or equal to ±2 °C, the sampler's temperature sensors are verified.

15) Replace both the ambient and filter temperature sensors.

B.5.3 Pressure Verification Check

A single-point pressure verification must be performed at least once every four weeks on each Partisol-FRM sampler. The pressure check is performed as follows:

1) Perform any required sample recovery from a previous sample run, if necessary.

2) Ensure that the sampler is in the STOP mode by pressing the F4 key in the Main Screen.

3) From the Main Screen, press F5 to access the Setup Screen.

4) From the Setup Screen, press F5 to access the Audit Screen.

5) Place the pressure transfer standard in proximity to the sampler. Be sure that pressure transfer standard is shaded from direct sunlight.

6) Read the pressure transfer standard reading, in millimeters of mercury, and the sampler pressure reading (from the sampler display), and record these values on the $PM_{2.5}$ Sampler Single-Point Calibration Verification Worksheet, Figure B.5.1. Make sure that the pressure transfer standard is reading in actual station pressure, *not sea level adjusted pressure*.

7) Calculate the difference between the pressure readings. If the sampler pressure is within ±10 mm Hg of the pressure transfer standard, the sampler's pressure is verified. If the pressure difference exceeds ±10 mm Hg, conduct a pressure calibration followed by another pressure verification check.

B.5.4 Single-Point Flow Verification Check

A single-point flow verification check must be performed at least once every four weeks on each Partisol-FRM sampler. The flow check is performed as follows:

1) Perform any required sample recovery from a previous sample run, if necessary.

2) If necessary, turn on the power to the flow transfer standard to allow it time to warm up. Expose the flow transfer standard to the ambient temperature, but keep the unit out of direct sunlight.

3) If not already completed, perform a single-point temperature check, a single-point pressure check, an external leak check, and an internal leak check.

4) Ensure that the sampler is in the STOP mode by pressing the F4 key in the Main Screen.

5) Install a filter cassette containing a Teflon® filter (designated for calibrations/leak checks) in the filter holder. Do not use a filter that is to be used for sampling.

6) Carefully lift straight up on the PM$_{10}$ inlet to remove it from the sampling tube.

7) Install the flow transfer standard onto the end of the sampling tube. If necessary, first install the supplied flow audit adapter and open its valve (valve fins vertical).

8) From the Main Screen, press F5 to access the Setup Screen.

9) From the Setup Screen, press F5 to access the Audit Screen.

10) Turn on the pump by pressing the F3 key.

11) Turn on the sample flow valve by pressing the F2 key.

12) If using the Streamline FTS flow transfer standard, enter the calibration constants “m” and “b” into the FRM Setup Screen as follows:

    a) Press the Esc key to return to the Setup Screen.

    b) Press F1 to enter the edit mode.

    c) Using the arrow keys, move the cursor to the “FTS CONST m” field.

    d) Using the keyboard, enter the “m” constant for the Streamline FTS flow transfer standard.

    e) Using the keyboard, enter the “b” constant for the Streamline FTS flow transfer standard.

    f) Press the Enter key.

    g) Press F5 to access the Audit Screen

13) Allow the sampler to warm up for 10 minutes before continuing.

14) Read and record the flow rate (actual L/min) from the flow transfer standard on the Single-Point Verification Worksheet. If using the Streamline FTS flow transfer standard, enter the pressure drop (inches water) in the Audit Screen as follows:

    a) Press F1 to enter the edit mode.

    b) Using the keyboard, enter the Streamline FTS pressure drop and press the Enter key.

    c) Read and record the actual flow rate as displayed on the FRM screen.

15) Read and record the sampler flow rate (actual lpm) from the sampler display on the Single-Point Verification Worksheet.

16) Turn off the pump by pressing the F3 key.

17) Calculate the flow rate percent difference as:

$$d=\left[\frac{(Audit\_Flow\_Rate)-(Sampler\_Flow\_Rate)}{(Audit\_Flow\_Rate)}\right]*100\%$$

18) If the flow rate percent difference (d) is greater than ±4 %, conduct a full multi-point calibration of the sampler flow. If the difference is less than or equal to ±4 %, the sampler's flow rate is within specifications.

19) Remove the flow transfer standard and reinstall the PM$_{10}$ inlet.

20) Remove the filter cassette from the sampler and discard it.

B.6 CALIBRATION

B.6.1 Sampler Calibration Equipment

The following is a list of the equipment necessary to perform calibrations on the Partisol-FRM sampler.

- A flow rate transfer standard that is certified against a National Institute for Standards and Technology (NIST) – traceable standard, capable of providing flow readings in actual (not standard) volumetric flow rate (lpm), and designed to connect either to the sample tube or the flow audit adapter. The flow rate transfer standard must have an accuracy of ±2 %.

- A temperature transfer standard that is certified against a NIST – traceable standard and possesses a resolution of 0.1 °C, and an accuracy of ±0.5 °C over the range of -30 to 45 °C.

- A barometric pressure transfer standard calibrated against a NIST – traceable primary standard with the capability to measure pressure over the range of 600 to 800 mm mercury (Hg), with a resolution of 1 mm Hg and an accuracy of ±5 mm Hg.

B.6.2 Calibration of Transfer Standards

All calibration transfer standards must be certified against NIST – traceable standards at least once per year. Calibration of these transfer standards will be conducted by the transfer standard manufacturer. The Idaho Bureau of Laboratories (IBL) will verify the response of temperature and pressure transfer standards at least once per year. If transfer standards are found to be out of specification, they will be returned to the manufacturer for recalibration.

B.6.3 Ambient Temperature Calibration

The ambient temperature calibration is to be performed upon initial installation and at any time thereafter when the sampler fails either a single-point or multi-point temperature verification check. To perform the ambient temperature calibration:

1) Perform any required sample recovery from a previous sample run, if necessary.
2) Ensure that the sampler is in the STOP mode by pressing the F4 key in the Main Screen.
3) From the Main Screen, press F5 to access the Setup Screen.
4) From the Setup Screen, press F2 to access the Calibration Screen.
5) Place the temperature transfer standard in proximity to the ambient temperature sensor. Be sure that both sensors are shaded from direct sunlight.
6) Read the temperature transfer standard reading in degrees Celsius.
7) Press the F1 key to enter the edit mode.
8) Using the arrow keys, move the cursor to the “Act” column in the row labeled “Amb T.”
9) Enter the actual ambient temperature on the sampler’s keypad and press Enter. To enter a negative number, first press and release the Shift key, then press F1 (±). This will enter the negative sign. Press and release the Shift key again and then enter the remainder of the number.
10) Conduct a multi-point temperature verification check.

B.6.4 Filter Temperature Calibration

The filter temperature calibration is to be performed upon initial installation and at any time thereafter when the sampler fails either a single-point or multi-point temperature verification check. To perform the filter temperature calibration:

1) Perform any required sample recovery from a previous sample run, if necessary.

2) Ensure that the sampler is in the STOP mode by pressing the F4 key in the Main Screen.

3) From the Main Screen, press F5 to access the Setup Screen.

4) From the Setup Screen, press F2 to access the Calibration Screen.

5) Place the temperature transfer standard in proximity to the filter temperature sensor. Be sure that both sensors are shaded from direct sunlight.

6) Read the temperature transfer standard reading in degrees Celsius.

7) Press the F1 key to enter the edit mode.

8) Using the arrow keys, move the cursor to the “Act” column in the row labeled “Flt T.”

9) Enter the actual filter temperature on the sampler’s keypad and press Enter. To enter a negative number, press and release the Shift key, then press F1 (±). This will enter the negative sign. Press and release the Shift key again and then enter the remainder of the number.

10) Conduct a multi-point temperature verification check.

B.6.5 Pressure Calibration Procedures

The pressure calibration is to be performed upon initial installation and at any time thereafter when the sampler fails a single-point pressure verification check. To perform the pressure calibration:

1) Perform any required sample recovery from a previous sample run, if necessary.

2) Ensure that the sampler is in the STOP mode by pressing the F4 key in the Main Screen.

3) From the Main Screen, press F5 to access the Setup Screen.

4) From the Setup Screen, press F2 to access the Calibration Screen.

5) Place the pressure transfer standard in proximity to the sampler. Be sure that the pressure transfer standard is shaded from direct sunlight.

6) Read the pressure transfer standard reading in millimeters of mercury.

7) Press the F1 key to enter the edit mode.

8) Using the arrow keys, move the cursor to the “Act” column in the row labeled “Pres.”

9) Enter the actual pressure on the sampler’s keypad and press Enter.

10) Conduct a pressure verification check.

B.6.6 Multi-Point Flow Calibration Procedure

A multi-point flow calibration must be performed upon initial installation and once per year thereafter. In addition, the multi-point calibration must be performed whenever a single-point flow verification check indicates that the sampler’s flow deviates from the flow transfer standard by more than ±4 %. The multi-point calibration is performed as follows:

1) Perform any required sample recovery from a previous sample run, if necessary.

2) If necessary, turn on the power to the flow transfer standard to allow it time to warm-up. Expose the flow transfer standard to the ambient temperature, but keep the unit out of direct sunlight.

3) If not already completed, perform a single-point temperature check, a single-point pressure check, an external leak check, and an internal leak check.

4) Ensure that the sampler is in the STOP mode by pressing the F4 key in the Main Screen.

5) Install a filter cassette containing a Teflon® filter (designated for calibrations/leak checks) in the filter holder. Do not use a filter that is to be used for sampling.

6) Carefully lift straight up on the PM$_{10}$ inlet to remove it from the sampling tube.

7) Install the flow transfer standard onto the end of the sampling tube. If necessary, first install the supplied flow audit adapter and open its valve (valve fins vertical).

8) From the Main Screen, press F5 to access the Setup Screen.

9) From the Setup Screen, press F2 to access the Calibration Screen.

10) If using the Streamline FTS flow transfer standard, enter the calibration constants “m” and “b” into the FRM Setup Screen as follows:

    a) Press the Esc key to return to the Setup Screen.

    b) Press F1 to enter the edit mode.

    c) Using the arrow keys, move the cursor to the “FTS CONST m” field.

    d) Using the keyboard, enter the “m” constant for the Streamline FTS flow transfer standard.

    e) Using the keyboard, enter the “b” constant for the Streamline FTS flow transfer standard.

    f) Press the Enter key.

    g) Press F2 to access the Calibration Screen

h) From the Calibration Screen, press F2 to access the Flow Calibration Screen.

i) Press F2 to start the calibration. The sampler display will indicate that it is computing the flow offset. Following this, the sampler will cycle through five different flow rates (16.7, 17.5, 15.8, 18.3, and 15.0 lpm). At each flow rate, the sampler will ask the user to enter the flow rate indicated by the flow transfer standard. If using the Streamline FTS flow transfer standard, use the following steps to enter the values:

   i) Wait for the flow readings on both the sampler and the Streamline FTS flow transfer standard to stabilize.

   ii) Read the pressure from the Streamline FTS flow transfer standard.

   iii) Press the F1 key to enter the edit mode.

   iv) Using the sampler keyboard, enter the pressure from the Streamline FTS flow transfer standard into the “FTS Pres” field and press the Enter key. The sampler will initiate the next flow rate.

k) Repeat steps i-iv for all five flow rates. After the fifth flow rate, the sampler will indicate “Calibration Complete.”

11) If not using the Streamline FTS flow transfer standard, use the following steps to enter the values:

   a) Wait for the flow readings on both the sampler and the flow transfer standard to stabilize.

   b) Read the flow rate from the flow transfer standard to the nearest 0.1 lpm.

   c) Press the F1 key to enter the edit mode.

   d) Enter the flow rate from the flow transfer standard on the sampler keypad and press the Enter key. The sampler will initiate the next flow rate.

   e) Repeat steps a-d for all five flow rates. After the fifth flow rate, the sampler will indicate “Calibration Complete.”

12) Perform a single-point flow verification check to verify that the sampler’s flow is within specifications.

13) Remove the flow transfer standard and reinstall the PM$_{10}$ inlet.

14) Remove the filter cassette from the sampler and discard it.

B.7 OPERATIONAL PROCEDURES

B.7.1 Office Preparatory Procedure for Filter Changes

1) Select a sample filter from the lot provided by the laboratory. Use filters in sequential order and ensure that the sample date for the specified filter will occur within 30 days of the filter tare weighing. In addition, take at least one spare sample filter.

2) Inspect both the primary and the spare filter for pinholes, tears, or other defects. Replace any defective filters.

3) Fill in the top portion of the Field Data Sheet, including the date/time of visit, the site identification, sampler identification, site name, filter identification number, sample start and stop dates and times, and field technician name.

B.7.2 Installing a New Filter and Setup for a New Sample

1) Perform all necessary pre-sampling procedures as described in Section B.7.1.

2) Perform any required sample recovery from a previous sample run, if necessary.

3) Ensure that the sampler is in the STOP mode by pressing the F4 key in the Main Screen.

4) Perform any of the following Quality Control / Quality Assurance (QC/QA) checks or maintenance activities listed in Table B.7.1.

5) Remove the next filter to be exposed from its protective anti-static bag and place into a clean filter carrier. Be sure not to touch the surface of the filter.

6) Place the filter carrier onto the lower filter holder making sure that the slot in the back of the filter carrier fits around the pin on the back edge of the filter holder, and that the hole in the front of the filter carrier rests over the short pin at the front of the filter holder.

7) Push forward (into the sampler) on the black handle of the filter mechanism, raising the filter into place against the bottom of the WINS impactor.

8) Gently push forward on the bottom half of the WINS impactor to ensure that the rubber lip seal on the bottom of the WINS impactor is seated squarely against the filter.

9) From the Main Screen, press F1 to access the Filter Setup Screen.

Table B.7.1
QA/QC Checks & Maintenance Activities

MAINTENANCE ACTIVITIES	FREQUENCY						
	@ Filter change	Every 5 Days	Every 14 Days	Monthly	Quarterly	Semi-Annually	Annually
Inspect Rubber Lip Seal @ Bottom of WINS impactor	X						
Inspect Rubber Lip Seal @ Top of Filter Holder	X						
Empty Water Collection Jar	X						
Conduct Sampler Internal Leak Check		X					
Conduct Sampler External Leak Check		X					
Clean or Exchange WINS impactor well		X					
Clean Sampler PM$_{10}$ Inlet			X				
Conduct a Single-Point Temperature Verification Check				X			
Conduct a Single-Point Pressure Verification Check				X			
Conduct a Single-Point Flow Verification Check				X			
Clean WINS impactor Housing				X			
Clean WINS impactor Jets				X			
Inspect Wins impactor O-rings				X			
Check Sampler Clock				X			
Inspect & Grease PM$_{10}$ Inlet O-rings					X		
Clean Sample Tube					X		
Inspect & Grease Bulkhead Fitting O-rings					X		
Inspect & Service WINS impactor assembly O-rings					X		
Inspect & Service Vacuum tubing					X		
Inspect & Service Fittings & other pneumatic equipment					X		
Inspect & Service Electrical Connections					X		
Exchange the large In-Line Filter						X	
Clean Air Screens						X	
Check System Board Battery Voltage						X	
Conduct a Multi-Point Temperature Verification Check							X
Conduct a Multi-Point Flow Verification Check							X
Perform a Pressure Calibration							X

10) Set date and time for the next sample – defaults already set. The Filter Setup Screen shows the start date and time and the end date and time for the next sample. Note that a time of 00.00 is midnight. If the default start time and duration were set during the initial sampler setup, conduct the steps 10a – 10e. If the default start time and duration were not set during installation, or if alternative start and stop times are desired, proceed to step 11.

    a) Press the F4 (+ Day) key repeatedly until the correct start day for the next sample run appears on screen. This should be the date on which the sample is to be taken. If the default duration has been setup correctly, the end date should automatically be correct.

    b) Press the F1 key to enter the edit mode.

    c) Use the arrow keys to move the cursor to the “ID2” field.

    d) On the sampler keypad, enter the 7-digit identification number of the filter placed onto the sampler and press the Enter key.

    e) Proceed to step 12.

11) Set date and time for the next sample – defaults not already set. If the default start time and duration were not set during sampler installation or if alternative times are required, perform the steps 11a – 11e, otherwise proceed to step 12.

    a) Press the F1 key to enter the edit mode.

    b) Using the arrow keys to move the cursor, position the cursor in the date or time field to be changed.

    c) Using the sampler keypad, enter the start date and time and the end date and time for the next sample. Note that midnight is entered as a time of 00.00 and that all other times are entered using a 24-hour clock (e.g., 1:00 pm would be entered as 13.00). Also note that the midnight time is associated with the date of the day that is just starting. For instance, if a sample is desired on July 15 from midnight to midnight, the start and stop times should both be 00.00. The start date should be 02/07/15 (year/month/day) and the stop date should be 02/07/16 (year/month/day).

    d) Use the arrow keys to move the cursor to the “ID2” field.

    e) On the sampler keypad, enter the 7-digit identification number of the filter placed onto the sampler and press the Enter key.

12) Press the Esc key to return to the Main Screen.

13) Verify that the sample start and stop dates and times are correct.

14) Press F4 to place the sampler in the WAIT mode.

B.7.3 Recovering the Sample and Data from a Completed Sample Run

(Note: Samples must be recovered within 96 hours of the completion of the sample run. In addition, due to limited laboratory holding times for exposed filters, the site technician should transport the recovered samples to IBL as soon as possible.)

1) From the Main Screen, read the current sampler status code (top line, left side of display). Write this status code on the Field Data Sheet for the completed sample. If this code is not “OK,” an error of some type has occurred. Follow sample recovery, initiate appropriate corrective action (see Section 6.1 of the Rupprecht & Patashnick Partisol-FRM Model 2000 operating manual).

2) From the Main Screen, note the current sampler operating mode (top line, right side of display). If the sampler is in the WAIT mode or the SAMP (sampling) mode, the sampler has not completed the previously scheduled sampling run. Do not disturb the sampler unless absolutely necessary.

3) If the sampler is in either the DONE mode or the ERR (error) mode, press the F4 key. This allows the sampler to write the final information into storage for the current sample run. This *must* be performed prior to filter exchange. The sampler mode should now indicate STOP.

4) Open the filter exchange mechanism by pulling straight back on the black handle. The filter holder will lower away from the WINS impactor.

5) Remove the filter carrier from the filter holder.

6) Remove the filter cassette from the filter carrier and place into an anti-static bag. Seal the bag.

7) Place the sealed bag into the sample transport cooler. Place the Styrofoam® insert and the digital maximum/minimum thermometer into the cooler on top of the sample. Allow the thermometer to equilibrate to the cooler temperature.

8) From the Main Screen, press F3 to access the Filter Data Screen.

9) Using the information displayed on the Filter Data Screen, complete the Field Data Sheet with the following information from the completed sample run:

    a) Total Sample Volume – from the “Vol” field

    b) Average Flow Rate – from the “AveFlow” field

    c) Coefficient of Variation – from the “%CV” field

    d) Total Run Time – from the “Tot” field

    e) Maximum Temperature Difference – from the “TempDiff” field

f) Minimum, Average, and Maximum Ambient Temperatures – from the “AmbT” fields

g) Minimum, Average, and Maximum Filter Temperatures – from the “FltT” fields

h) Minimum, Average, and Maximum Pressures – from the “Pres” fields

10) Once the temperature on the sample transport cooler thermometer has stabilized, reset the maximum/minimum temperatures.

11) Insert the completed Field Data Sheet into the cooler. Close the sample cooler and prepare for shipment.

12) If any of the sample run data validation criteria are out of range, retrieve the interval data (5-minute data) from the sampler using a laptop or palmtop computer as follows (alternatively, the data may be regularly retrieved via telephone modem if the site is configured accordingly):

(Note: The following steps assume that the operator has access to a laptop or palmtop computer, that the AKCOMM software has been installed on the computer, that the appropriate communication settings were entered during sampler installation, and that the matching settings have been configured in the AKCOMM software. In addition, the following commands all refer to key entries on the laptop/palmtop computer, not the sampler keypad.)

a) Connect the serial (COM) port of the computer to the RS-232 port on the front of the sampler using the 9-pin cable provided with the sampler or a suitable alternative. A null-modem *is not* required for laptop computer connections. A null-modem *is* required for palmtop computer connections.

b) Run the AKCOMM software provided with the sampler from either a DOS prompt or a Windows icon.

c) Using the arrow keys, select the menu item labeled “Request the value of a register” and press Enter.

d) The software will present the prompt “Enter PRC number: “ Type “38” and press Enter. This register contains a flag for the storage download type. The code “1” is for filter data and “2” is for interval data. To download interval data, verify that this register code is “2.”

e) If the register code is not “2,” it needs to be reset. Using the arrow keys, select “Modify the value of a register” and press Enter. The software will present a prompt that says “Enter the PRC number to change.” Type “38” and press Enter. The prompt “Enter a new value for PRC 38“ will appear. Type “2” and press Enter. Repeat step d to ensure that the register now contains the code ” 2.”

f) Using the arrow keys, select the menu command “Download storage” and press Enter.

g) When prompted for the number of records to download, type “A” and press Enter. This requests all records that have not previously been downloaded.

h) The software will ask for the file name under which to store the data. Enter a suitable file name and press Enter.

i) If the file name already exists, the software will ask whether you wish to append. If you wish to add to the existing file, type “Y” and press Enter.

j) If you do not wish to add to the existing file, type “N” and press Enter. The software will prompt for a new file name. The software will not allow the user to overwrite an existing file.

k) The software will indicate the number of records to download and will show the download progress.

l) Once the download is complete, use the arrow keys to select “Exit program” and press Enter.

m) Disconnect the computer from the sampler.

n) Archive the downloaded file for future use.

(Note: If it is desirable to obtain an electronic copy of the filter data, follow the procedures described above in step 12, except that the value in Register 38 should be set to “1” to obtain filter data.)

13) Prepare the sampler for its next sample run.

B.7.4 Backing Up the Sample Data from a Completed Sample Run

If the sample run data is to be retrieved on site for manual backup, a laptop or palmtop computer with properly installed AKCOMM software, and the appropriate communications settings entered into both the sampler and the AKCOMM software is required. Execute the following commands, using the laptop/palmtop computer keyboard to accomplish the back up.

1) Connect the serial (COM) port of the computer to the RS-232 port on the front of the sampler using the 9-pin cable provided with the sampler or a suitable alternative. A null-modem *is not* required for laptop computer connections. A null-modem *is* required for palmtop computer connections.

2) Run the AKCOMM software provided with the sampler from either a DOS prompt or a Windows icon.

3) Using the arrow keys, select the menu item labeled “Request the value of a register” and press Enter.

4) The software will present the prompt “Enter PRC number: “ Type “38” and press Enter. This register contains a flag for the storage download type. The code “1” is for filter data and “2” is for interval data. To download interval data, verify that this register code is “2.”

5) If the register code is not “2,” it needs to be reset. Using the arrow keys, select “Modify the value of a register” and press Enter. The software will present a prompt that says “Enter the PRC number to change.” Type “38” and press Enter. The prompt “Enter a new value for PRC 38“ will appear. Type “2” and press Enter. Repeat step d to ensure that the register now contains the code ” 2.”

6) Using the arrow keys, select the menu command “Download storage” and press Enter.

7) When prompted for the number of records to download, type “A” and press Enter. This requests all records that have not previously been downloaded.

8) The software will ask for the file name under which to store the data. Enter a suitable file name and press Enter.

   a) If the file name already exists, the software will ask whether you wish to append. If you wish to add to the existing file, type “Y” and press Enter.

   b) If you do not wish to add to the existing file, type “N” and press Enter. The software will prompt for a new file name. The software will not allow the user to overwrite an existing file.

9) The software will indicate the number of records to download and will show the download progress.

10) Once the download is complete, use the arrow keys to select “Exit program” and press Enter.

11) Disconnect the computer from the sampler.

12) Archive the downloaded file for future use.

B.8 DATA CALCULATIONS AND VALIDATION

The following subsections describe the routine procedures used to calculate 24-hour PM$_{2.5}$ concentrations and to validate individual samples.

B.8.1. Data Calculations

1) From the Field Data Sheet or the electronic filter data (downloaded from the FRM sampler), determine the total sample volume (V_a) for the sample run. If the total sample volume is not available it can be calculated from the average volumetric flow rate (Q_{avg}) and the total sample duration (t) as follows:

$$V_a = (Q_{avg})(t)(10^3)$$

Where:

V_a	= total sample volume (actual m^3)
Q_{avg}	= average sample flow rate (lpm)
t	= total sample duration (min)
10^3	= units conversion (m^3/L)

2) Using the final weight and tare weight of the sample filter, determine the total filter mass gain ($M_{2.5}$):

$$M_{2.5} = (M_f - M_I)(10^3)$$

Where:

$M_{2.5}$	= total mass gain (μg)
M_f	= final filter weight (mg)
M_I	= initial (tare) filter weight (mg)
10^3	= units conversion (μg/mg)

3) Calculate the $PM_{2.5}$ concentration:

$$PM_{2.5} = M_{2.5} / V_a$$

B.8.2 Data Validation

The following steps apply to the validation of single $PM_{2.5}$ concentrations based upon field and laboratory data. Additional validation techniques (i.e., statistical techniques) may be specified in the Quality Assurance Project Plan (QAPP). Invalidated data should be flagged for QA review and an explanation should be noted in the free-form notes section on the Field Data Sheet.

1) Verify that the run data from the FRM are within the following limits:

Average volumetric flow rate	= 16.67 lpm ±5%
Flow rate coefficient of variation	$\leq$ ±4 %
Total sample duration	= 24 hours ±1 hour
Temperature difference (filter-ambient)	$\leq$ 5 °C

2) Verify that the post-run sampler status code was “OK” and that the sampler mode was not ERR.

3) Verify that the site technician did not flag the sample as “questionable” on the Field Data Sheet.

4) Verify that free-form notes on the Field Data Sheet do not indicate an invalid sample.

5) Verify that the sample was recovered from the FRM within 96 hours of the completion of the sample run.

6) Verify that the sample cooler temperature did not exceed 25 °C during shipment to IBL.

7) Verify that the sample holding times (30 days if the filter temperature prior to conditioning was maintained less than 4 °C; 10 days otherwise) were not exceeded.

8) Verify that the sample was not invalidated by laboratory personnel.

B.9 SAMPLER MAINTENANCE

The EPA reference method for $PM_{2.5}$ specifies a large number of maintenance items to ensure that the collected samples meet the $PM_{2.5}$ monitoring program data quality objectives. These maintenance items are listed below, grouped by the frequency of required maintenance.

B.9.1 Five-Day Maintenance

The following maintenance items are to be serviced every five sample days:

1) Service Water Collection Jar: Inspect the water collection jar on the PM_{10} inlet and empty if necessary. To empty the jar, unscrew the glass collector jar from the black metal top, empty the jar, and replace. Ensure that a tight seal is made between the jar and the metal top.

2) WINS Impactor Well: Clean the WINS impactor well according to the following instructions:

   a) Perform any required sample recovery from a previous sample run, if necessary.

   b) Ensure that the sampler is in the STOP mode by pressing the F4 key in the Main Screen.

   c) Open the filter exchange mechanism by pulling out on the black handle.

   d) Push back on the filter exchange mechanism slightly and lift the metal rollers through the slots on the guides.

   e) Let the filter holder settle downward, away from the WINS impactor.

   f) Remove the WINS impactor with a downward motion.

   g) Separate the WINS impactor from the adapter (below the impactor).

   h) Grasp the top and bottom halves of the WINS impactor and unscrew the two halves.

   i) Remove the impactor well assembly from the bottom half of the WINS impactor.

   j) Remove the top of the impactor well assembly by lifting upward.

   k) Remove any previously installed filter from the impactor and discard. Clean the top and bottom using a dry paper towel. If necessary, use a general-purpose cleaner.

l) Inspect the O-ring in the top of the impactor well assembly. Replace or lubricate with O-ring lubricant, if necessary.

m) Place a new 37-mm borosilicate glass filter into the impactor well to retain particles of size larger than 2.5 micrometers (μm).

n) Lubricate the filter with 42 to 44 drops (1 ml) of impactor oil.

o) Reassemble the impactor well and the WINS impactor. Be sure to keep the unit upright during reassembly to prevent spillage of the impactor oil.

p) Reinsert the WINS impactor into the adapter.

q) Insert the WINS impactor and adapter back into the sampler.

r) Pass the rollers on the filter exchange mechanism through the slots on the guides.

s) Pull on the black handle to fully open the filter exchange mechanism.

(Note: To reduce field service time, spare impactor wells can be prepared. Field servicing would then involve only the exchange of the impactor wells.)

3) Sampler Leak Check: Perform a sampler leak check as described in the Partisol-FRM Model 2000 PM$_{2.5}$ Operating Manual's Section 9.2.4.

B.9.2 Fourteen-Day Maintenance

Clean the PM$_{10}$ Inlet every 14 sample days following these steps:

1) Remove the sampler inlet by gently lifting the complete inlet upward off the aluminum sample tube. Disassemble the upper and lower inlet halves by unscrewing the top acceleration assembly from the lower collector assembly.

2) Clean the top acceleration assembly. Mark the top plate deflector cone and lower plate with a pencil to facilitate proper orientation during reassembly. Remove the four Phillips-head screws from the top and lift the top plate off. Clean the insect screen with general-purpose cleaner and a brush and clean the top plate deflector cone and internal surface of the acceleration assembly. Check the O-rings. Reassemble the acceleration assembly.

3) Clean the lower collector assembly. Clean the threads on the lower collector assembly. Using a general-purpose cleaner, clean the collector assembly walls and bottom side as well as the three vent tubes. Clean the drain hole and rain collection jar. Inspect the brass nipple connected to the water collection jar for blockage. Clean if necessary.

4) Apply a light coating of silicone vacuum grease to the cork gasket inside the cap of the collection jar. Grease the two inlet-to-male-inlet tube sealing O-rings.

5) Reassemble the two halves of the PM_{10} inlet; hand-tighten only.

6) Reinstall the PM_{10} inlet on the sample tube.

B.9.3 Monthly Maintenance

Clean the WINS impactor housing and impactor jets monthly following these steps:

1) Perform any required sample recovery from a previous sample run, if necessary.

2) Ensure that the sampler is in the STOP mode by pressing the F4 key in the Main Screen.

3) Open the filter exchange mechanism by pulling out on the black handle.

4) Push back on the filter exchange mechanism slightly and lift the metal rollers through the slots on the guides.

5) Let the filter holder settle downward, away from the WINS impactor.

6) Remove the WINS impactor with a downward motion.

7) Separate the WINS impactor from the adapter (below the impactor).

8) Grasp the top and bottom halves of the WINS impactor and unscrew the two halves.

9) Service the WINS impactor well, if necessary.

10) Clean the inside of the WINS impactor housing and impactor jets using a dry paper towel and/or cotton swabs. Use an all-purpose cleaner, if necessary.

11) Reassemble the impactor well and the WINS impactor. Be sure to keep the unit upright during reassembly to prevent spilling the impactor oil.

12) Reinsert the WINS impactor into the adapter.

13) Insert the WINS impactor and adapter back into the sampler.

14) Pass the rollers on the filter exchange mechanism through the slots on the guides.

15) Pull on the black handle to fully open the filter exchange mechanism.

B.9.4 Quarterly Maintenance

1) Inspect and grease the PM$_{10}$ inlet O-rings. Remove the PM$_{10}$ inlet and inspect the O-rings that seal the sample tube. Replace or lubricate the O-rings as necessary.

2) Clean the sample tube and inspect the bulkhead fitting O-rings following these steps:

   a) Remove the PM$_{10}$ inlet from the sample tube by pulling straight up.

   b) Loosen the nut on the bulkhead fitting at the top of the FRM enclosure.

   c) Slide the sample tube up and out of the bulkhead fitting. Be sure to note which end of the sample tube goes into the bulkhead fitting.

   d) Clean the inside of the sample tube using dry paper towel or a suitable brush. Use a general-purpose cleaner, if necessary.

   e) Inspect the bulkhead fitting O-rings. Replace or lubricate the O-rings, as necessary.

   f) Insert the correct end of the sample tube into the bulkhead fitting and gently push until the tube stops.

   g) Tighten the nut on the bulkhead fitting to ensure a watertight fit.

   h) Reinstall the PM$_{10}$ inlet on top of the sample tube.

   i) Perform a sampler leak check.

3) Inspect the vacuum tubing, pneumatic connections, fittings, and electrical connections for excessive wear. Replace as necessary.

B.9.5 Semi-Annual Maintenance

1) Replace the in-line air filter as described below.

   a) Open the FRM door and remove the four screws holding the bottom access cover to the pump compartment. Be careful not to lose the lock washer that holds the electrical grounding connection to the lower right-hand screw.

   b) Locate the large in-line filter in the top of the pump compartment.

   c) Remove the filter. Be careful to note the direction of flow as indicated on the side of the filter. Be sure to install the replacement filter in the same direction.

   d) Install the replacement filter.

e) Perform a sampler external leak check and internal leak check.

f) Reattach the pump and the compartment cover. Be sure to secure the electrical grounding wire to the lower right-hand screw.

2) Clean the air screens following these steps:

a) Remove the three rain hoods that cover the vents on the side of the FRM enclosure. Each vent is covered with a removable air screen.

b) Remove the air screens and clean with water. Dry thoroughly before reassembling.

c) Reassemble the air screens and reattach the rain hoods.

3) Check the system board battery voltage following the steps listed below.

a) Turn off the sampler and disconnect the FRM from the power source.

b) Open the door to the electronics compartment (behind the sampler display).

c) Test both of the batteries on the circuit board at the back of the electronics compartment.

d) Test the round battery on the circuit board. Measure the voltage across the ground ("GND") test point in the center of the interface board and the top of the round battery. This voltage should be at least 2.5 Direct Current Voltage (VDC). Replace if necessary.

e) Test the socket battery. Measure the voltage across pins 14 and 28 on the electronics component "U4". This voltage should be at least 2.5 VDC. Replace the socket battery if necessary.

f) Close the electronics compartment door. Reconnect the sampler to the power source and turn the sampler on.

g) If either battery was replaced, follow the installation procedures in this SOP to ensure that the sampler clock is set, the default sampling times are entered, and the sampler is calibrated.

B.10 PERFORMANCE AUDITS

Performance audits are designed to evaluate the accuracy of the FRM sampler in measuring the key parameters involved in collecting a valid PM$_{2.5}$ sample. The parameters are the volumetric flow rate, ambient air temperature, filter temperature, and barometric pressure. Performance audits should be conducted in accordance with the frequency and personnel requirements specified in the QAPP. In general, however, performance audits are to be conducted by personnel not directly involved in the routine operation of the PM$_{2.5}$ monitoring network or in processing or reporting data from the network. Furthermore, performance audits are to be conducted using transfer standards different from those used in the routine calibration and operation of a sampler. It is acceptable for the audit transfer standards to be certified against the same local primary standard as the routine transfer standards.

There are three distinct components to the performance audit:

- a temperature audit,
- a pressure audit, and
- a flow rate audit.

Each of these components is described separately below.

B.10.1 Multi-Point Temperature Audit

To conduct a multi-point temperature audit:

1) Have the site operator perform any required sample recovery from a previous sample run, if necessary.

2) Ensure that the sampler is in the STOP mode by pressing the F4 key in the Main Screen.

3) Prepare three stable thermal masses of 0 °C, ambient temperature, and approximately 40 °C. The low temperature thermal mass is prepared by mixing water with crushed ice to form a slurry in an insulated thermos bottle. The ambient and hot temperature thermal masses are prepared by placing ambient temperature or hot (40 °C) water in an insulted thermos bottle.

4) From the Main Screen, press F5 to access the Setup Screen.

5) From the Setup Screen, press F5 to access the Audit Screen.

6) Remove the ambient temperature sensor from its radiation shield by loosening the two screws located at the bottom of the shield and sliding the sensor out of the shield.

7) Remove the filter temperature sensor from the lower half of the filter holder. This is accomplished by loosening the retaining nut on the bulkhead fitting and sliding the temperature sensor out of the filter holder. Pull enough slack in the filter temperature sensor wire to be able to locate the filter temperature sensor out of the sampler door.

8) Using two rubber bands, wrap the ambient temperature sensor, the filter temperature sensor, and the temperature audit transfer standard together with the sensor tips next to one another.

9) Immerse the temperature sensors in the ambient temperature bath and stir the bath. Continue stirring the bath until the readings on all three temperature sensors have stabilized.

10) Read the temperature audit transfer standard reading, the filter temperature reading (from the sampler display), and the ambient temperature reading (from the sampler display) and record these values on the Multi-Point Audit Worksheet.

11) Remove the temperature sensors from the ambient temperature bath.

12) Repeat steps 9-11 above for each thermal mass in the order of AMBIENT – COLD – AMBIENT – HOT – AMBIENT until three readings have been obtained for each temperature range.

13) For each set of temperature readings, calculate the difference between the temperature audit transfer standard readings and both the ambient temperature reading and the filter temperature reading. For each temperature range (cold, ambient, hot), calculate the average temperature difference for the five readings. If any of the average differences exceed ±2 °C, repeat the audit. If the temperatures are still out of specification, have the operator initiate corrective action. If all of average temperature differences are less than or equal to ±2 °C, the sampler passes the temperature audit.

14) Replace both the ambient and filter temperature sensors.

B.10.2 Pressure Audit

The pressure audit is performed as follows:

1) Have the site operator perform any required sample recovery from a previous sample run, if necessary.

2) Ensure that the sampler is in the STOP mode by pressing the F4 key in the Main Screen.

3) From the Main Screen, press F5 to access the Setup Screen.

4) From the Setup Screen, press F5 to access the Audit Screen.

5) Place the pressure audit transfer standard in proximity to the sampler. Be sure that pressure audit transfer standard is shaded from direct sunlight.

6) Read the pressure audit transfer standard reading, in millimeters of mercury, and the sampler pressure reading (from the sampler display) and record these values on the Audit Worksheet. Make sure that the pressure audit transfer standard is reading in actual station pressure, *not sea level adjusted pressure*.

7) Calculate the difference between the pressure readings.

8) Repeat steps 5-7 two more times to obtain three sets of pressure measurements.

9) Calculate the average pressure difference from the three sample pairs.

10) If the average pressure difference is less than ±10 mm Hg, the sampler passes the audit. If the average pressure difference exceeds ±10 mm Hg, repeat the audit. If the pressure is still out of specification, have the site operator initiate corrective action.

B.10.3 Single-Point Flow Audit

The flow audit is performed as follows:

1) Have the site operator perform any required sample recovery from a previous sample run, if necessary.

2) If necessary, turn on the power to the flow audit transfer standard to allow it time to warm up. Expose the flow audit transfer standard to the ambient temperature, but keep the unit out of direct sunlight.

3) Ensure that the sampler is in the STOP mode by pressing the F4 key in the Main Screen.

4) Install a filter cassette containing a new Teflon® filter in the filter holder. Do not use a filter that is to be used for sampling.

5) Carefully lift straight up on the PM$_{10}$ inlet to remove it from the sampling tube.

6) Install the flow audit transfer standard onto the end of the sampling tube. If necessary, first install the supplied flow audit adapter and open its valve (valve fins vertical).

7) From the Main Screen, press F5 to access the Setup Screen.

8) From the Setup Screen, press F5 to access the Audit Screen.

9) Turn on the pump by pressing the F3 key.

10) Turn on the sample flow valve by pressing the F2 key.

11) If using the Streamline FTS flow transfer standard, enter the calibration constants “m” and “b” into the FRM Setup Screen as follows:

    a) Press the Esc key to return to the Setup Screen.

    b) Press F1 to enter the edit mode.

    c) Using the arrow keys, move the cursor to the “FTS CONST m” field.

    d) Using the keyboard, enter the “m” constant for the Streamline FTS flow transfer standard.

    e) Using the keyboard, enter the “b” constant for the Streamline FTS flow transfer standard.

f) Press the Enter key.

g) Press F5 to access the Audit Screen

12) Allow the sampler to warm up for 10 minutes before continuing.

13) Read and record the flow rate (actual lpm) from the flow transfer standard on the Audit Worksheet. If using the Streamline FTS flow transfer standard, enter the pressure drop (inches of water [in H_2O]) in the Audit Screen as follows. The conversion factor between mm Hg and in H_2O is 13.6(mm Hg)/(in H_2O):

a) Press F1 to enter the edit mode.

b) Using the keyboard, enter the FTS pressure drop and press the Enter key.

c) Read and record the actual flow rate as displayed on the FRM screen.

14) Read and record the sampler flow rate (actual lpm) from the sampler display on the Audit Worksheet.

15) Turn off the pump by pressing the F3 key.

16) Calculate the flow rate percent difference as:

$$d=\left[\frac{(Audit\_Flow\_Rate)-(Sampler\_Flow\_Rate)}{Audit\_Flow\_Rate}\right]*100\%$$

17) Repeat steps 12-15 two more times to obtain three flow rate comparisons.

18) Calculate the average of the flow rate percent difference.

19) If the average flow rate percent difference (d) is greater than ±4 %, perform the audit again. If the flow rate is still out of specification, have the operator initiate corrective action. If the difference is less than or equal to ±4 %, the sampler passes the audit.

20) Remove the flow audit transfer standard and reinstall the PM$_{10}$ inlet.

21) Remove the filter cassette from the sampler and discard it.

B.10.4 Performance Audit Reporting

Upon completion of a performance audit, immediately inform the site operator of the audit results so that corrective action may be taken, if necessary. Within 30 days of the completion of the audit, prepare an audit report and submit it to the Monitoring, Modeling, and Emissions Inventory (MMEI) coordinator at the Department of Environmental Quality's State Office.

APPENDIX C: PM$_{2.5}$ SEQUENTIAL SAMPLER

State of Idaho
Division of Environmental Quality

PARTISOL®–PLUS MODEL 2025

SEQUENTIAL AIR SAMPLER PROCEDURE

October 1999

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Partisol®-Plus Model 2025 Sequential Air Sampler

FIGURES

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Acronyms, Units, And Chemical Nomenclature

ADT	Average Daily Traffic
DEQ	Department of Environmental Quality
IBL	Idaho Bureau of Laboratories
MFC	Mass Flow Controller
NIST	National Institute of Standards and Technology
SOP	Standard Operating Procedure
VDC	Volts Direct Current
WINS	Wedding and Associates Inertial Separator

C.1 INTRODUCTION

This document describes the procedures used to sample $PM_{2.5}$ (particulate matter that has an aerodynamic diameter of 2.5 micrometers [μ] or less) by the Idaho Department of Environmental Quality's Ambient Air Quality Monitoring Program. A Partisol®–Plus Model 2025 Sequential Air Sampler draws a known volume of ambient air at a constant flow rate through a size-selective inlet followed by a WINS impactor (particle size separator). Particles in the $PM_{2.5}$ size range are then collected on a Teflon® filter during a specified 24-hour sampling period. Each sample filter is weighed before and after sampling to determine the net weight (mass) gain of the collected $PM_{2.5}$ sample. This mass concentration is reported as micrograms per cubic meter at ambient conditions. The reference method for $PM_{2.5}$ sampling is given in the Code of Federal Regulations (40 CFR Part 50, Appendix L).

This document is intended to be used together with the sampler-specific information and instructions provided by the manufacturer of the $PM_{2.5}$ sampler in the sampler's operation or instruction manual.

Figure C.1.1 is a schematic drawing showing the inlet head of the $PM_{2.5}$ sampler. The inlet is designed to remove particles with aerodynamic diameter greater than 10 micrometers (μm) and to send the remaining smaller particles to the next stage. Figure C.1.2 depicts the WINS impactor that removes particles greater than 2.5 μm and allows 2.5 μm in diameter and smaller particles to be collected on a Teflon® filter surface. The design flow rate through the inlet is 16.7 liters per minute (L/min).

The Partisol®–Plus Model 2025 Sequential Air Sampler uses a filter cassette magazine that simplifies filter exchange and transport and minimizes the risk of filter contamination during these procedures. The supply magazine contains pre-weighed filters for sample collection and the storage magazine receives the exposed filters.

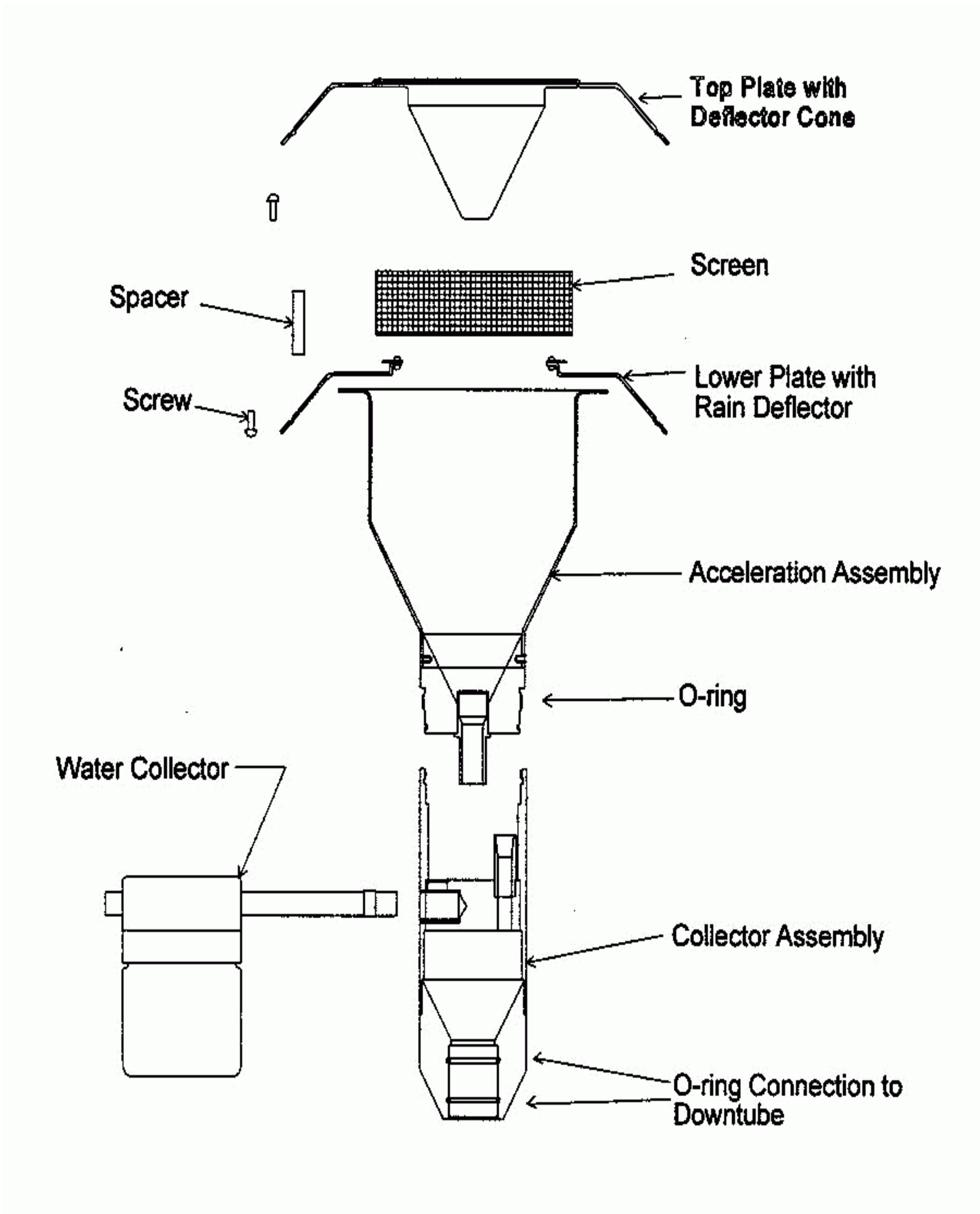

Figure C.1.1 Exploded Cross-Sectional View of PM$_{2.5}$ Sampler Inlet Head

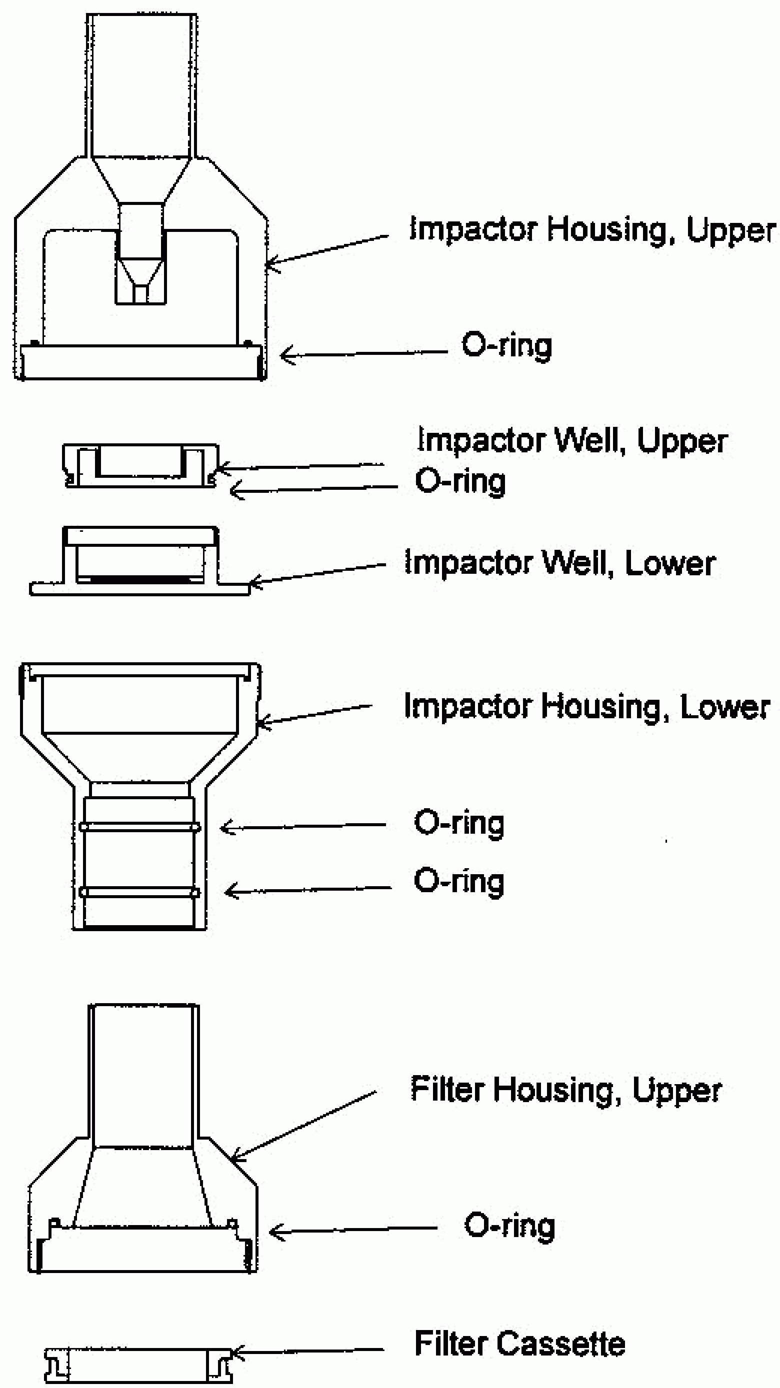

Figure C.1.2 Exploded Cross-sectional View of PM$_{2.5}$ Impactor Well and Filter Holder

C.2 EQUIPMENT AND SUPPLIES

The following list of parts and supplies must be maintained on hand to support the Partisol®–Plus Model 2025 Sequential Air Sampler.

- Additional sampler parts and supplies consisting of WINS impactors, impactor oil, 37-millimeter (mm) glass impactor filters, filter cassettes, inlet O-rings, and filter magazines.
- 47 mm Teflon® filters.
- Filter magazine transportation cooler equipped with thermometer.
- Calibration equipment as defined in Section C.3.
- Laboratory equipment as defined in Section C.5.
- Miscellaneous hand tools, soft brushes, cotton swabs, calculator, lent-free clothes, worksheets, and miscellaneous sampler spare parts including additional gaskets/seals.
- Logbook.

C.3 CALIBRATION AND VERIFICATION PROCEDURES

Because PM$_{2.5}$ concentration standards are not available for determining calibration relationships, individual components of the sampling method must be calibrated to ensure the integrity of reported data.

C.3.1 Flow-Rate Measurement

This section describes the procedures involved in calibrating the temperature, pressure, and flow sensors incorporated in the Partisol®-Plus Sampler. United States Environmental Protection Agency (EPA) monitoring network requirements for calibration can be found in *Quality Assurance Handbook*, Section 6, Page 36.

The sampler's Mass Flow Controller (MFC) operates under the control of the sampler's microprocessor and maintains the sample air stream at a constant volumetric flow rate of 16.67 L/min through the use of ambient temperature and pressure sensors.

The calibration of the MFC is achieved by calibrating the flow rate with a National Institute for Standards and Technology (NIST)-traceable flow device. The temperature sensor is calibrated with a NIST-traceable thermometer while the pressure sensor is calibrated using a barometer traceable to a laboratory grade mercury barometer.

The time on the data logger will be used to maintain and verify accurate time on the Partisol®-Plus samplers.

C.3.2 Air Sampler Orifice Calibration Procedure

C.3.2.1 Calibration Equipment

Following is a list of necessary equipment for the calibration of the air sampler orifice device.

- A transfer standard (bubble meter, orifice) with proper calibration traceable to NIST.
- An associated manometer with a 0- to 10-inch range and minimum scale divisions of 0.1 inches.
- A thermometer capable of accurately measuring temperature over the range of -30 to 50 °C (243 to 323K) to the nearest ± 0.1 °C and referenced to an NIST thermometer within ± 0.5 °C at least annually.
- A portable aneroid barometer (e.g., a climber's or engineer's altimeter), capable of accurately measuring ambient barometric pressure within ±1 mm mercury (Hg) resolution and referenced within ±5 mm Hg to a barometer referenced to a NIST standard.
- A clean filter.

C.3.2.2 Verification Procedures

The following describes the procedures involved in verifying the calibration of the Partisol®-Plus Sampler.

NOTE: The procedures vary on whether you start from the **Stop** or **Sampling** modes. It is important that the verification described in this section be performed in the order presented.

Verification or audit of any parameters must be performed when the sampler is in the **Sampling** mode or **Wait** mode.

To verify or audit any parameters while in the **Sampling** or **Wait** modes, follow the procedure below:

1) Press <Run/Stop>.

2) Press <F1: Audit>; press any key to continue.

3) Press <MENU> twice; Select <Audit>, Press <Enter>.

4) When the audit is complete, press <Run/Stop> to continue sampling.

5) Press <Esc> twice to return to Main Menu Screen.

6) Insert a filter cassette containing a new 47mm filter in the topmost position in the filter cassette supply tube.

Perform a verification of the ambient air temperature in the **Audit** mode in the following manner:

1) Determine the current temperature (°C) at the ambient temperature sensor using an external thermometer by inserting the external thermometer probe into the ambient air temperature radiation shield.

2) Verify that the value of <Amb T> displayed in the Audit Screen is within ±4 °C of the measured temperature. If this is not the case, perform the ambient temperature calibration procedure.

C.3.2.3 Calibration Procedures

The screens that support the user's calibration activities are located in the **Service** mode of the Partisol®-Plus Sampler. **It is important that the procedures described in this section be performed in the order in which they appear.**

To calibrate any parameter, the sampler must be in **Stop** mode. Follow the procedure below to enter the **Service** mode from the **Stop** mode.

1) Insert a filter cassette containing a new 47-mm filter in the topmost position in the filter cassette supply magazine.

2) Press <MENU> to display the Master Menu. Scroll to the Service Menu, press <Enter>.

3) Press <F2:Audit> to display the Audit Screen.

4) Press <F4:FiltAdv> to move the filter into the sampling position.

Execute the steps below to return to the **Stop Operating** mode from the **Service** mode:

1) Press <MENU> to display the **Service** mode.

2) Select the <EXIT SERVICE MODE> option to return to the Stop Operating mode.

C.3.2.4 Ambient Air Temperature Calibration

Calibration of the Partisol®-Plus is done only in the **Stop Operating** mode.

Calibrate the ambient air temperature in the following manner:

1) Press <MENU> to enter the Service Menu. With the cursor pointing to "Calibration/Audit," press <F3:SensCal> to access the Sensor Calibration Screen.

2) Loosen the two screws on either side of the temperature probe on the ambient temperature assembly and remove the probe from the radiation shield. The reference and sampler probes should be banded together and immersed to the same depth in an insulated constant temperature bath or block. One of the temperatures measured should be in an ice slurry, another temperature should be at ambient conditions, and the third should be in lukewarm water. The reference and sampler probes should be equilibrated for at least five minutes at each temperature before the temperature is measured. A series of three measurements should be taken about one minute apart. The average ambient temperature measurement shall be used in the next step.

3) Press <Edit>, then enter the average ambient reference temperature in degrees Celcius in the "Actual" column of the "Amb Temp" row of the Sensor Calibration Screen and press <Enter>. The sampler automatically adjusts the corresponding offset based upon this input. Write down this offset number in the logbook.

4) Perform a single point temperature verification to validate the calibration.

5) Reinstall the ambient temperature probe in the radiation shield and tighten the two screws on either side of the probe.

C.3.2.5 Filter Compartment Temperature Calibration

Perform a single point calibration of the filter compartment temperature in the following manner:

1) Press <MENU> to enter the Service Menu. With the cursor pointing to "Calibration/Audit," press <F4:FiltCal> to enter the Filter Temperature Calibration Screen.

2) Using an external thermometer, determine the current temperature at the location of the filter compartment probe in the sampler.

3) Press <Edit> and enter the measured filter compartment temperature in degrees Celcius in the "Actual" column of the "Filt Comp" row of the Filter Temperature Calibration Screen and press <Enter>. The sampler automatically adjusts the corresponding offset based upon this input. Write down this offset number in the logbook.

C.3.2.6 Verifying Filter Temperature

Verify the filter temperature in the following manner:

1) Insert an empty filter cassette (without filter and support screen) in the topmost position in the filter cassette magazine.

2) Press <F4:FiltAdv> to move the empty cassette into the sampling position.

3) Open the top section of the sampler and remove the WINS impactor. Insert an external thermometer through the top, positioning it next to the filter temperature probe, and determine the current temperature (°C) at the filter temperature sensor, using an external thermometer.

4) Verify that the value of "Filt Temp" displayed in the Audit Screen is within ±4 °C of the measured temperature. If this is not the case, perform the filter temperature calibration procedure.

5) Remove the external temperature thermometer and reinstall the WINS impactor and close the top section. Perform an external leak check to ensure that WINS impactor is reinstalled properly and that there are no leaks.

C.3.2.7 Filter Temperature Calibration

Perform filter temperature calibration in the following manner:

1) Press <MENU> to enter the Service Menu. With the cursor pointing to "Calibration/Audit," press <F4:FiltCal> to enter the Filter Temperature Calibration Screen.

2) Remove both sampling magazines from the sampler. Loosen the two screws (in some cases three screws) on either side of the filter temperature probe in the sampling platform of the filter compartment and remove the temperature probe from the sampling platform.

3) Note the depth and location of the filter temperature probe in the sampling platform of the ventilated filter compartment.

4) The reference thermometer and sampler probe should be banded together and immersed to the same depth in an insulated constant temperature bath or block. One of the temperatures measured should be an ice slurry, another should be at ambient conditions, and the third temperature should be in lukewarm water. Reference and sampler probes should be equilibrated for at least five minutes before the temperature is measured. A series of three measurements shall be made at approximately one-minute intervals. The average ambient temperature shall be used for the next step.

5) Press <Edit> and enter the measured filter temperature in degrees Celsius in the "Actual" column of the "Filter" row of the Filter Temperature Calibration Screen and press <Enter>. The sampler automatically adjusts the corresponding offset based upon this input. Write down this offset number in the logbook.

6) Reinstall the filter temperature probe into the sampling platform to the depth marked in step 3 above. Tighten the two screws to hold probe at the correct depth.

7) Perform a single point temperature verification to validate the calibration.

C.3.2.8 Verifying Ambient Pressure

Verify the ambient pressure in the following manner:

1) Determine the current ambient pressure in millimeters of Hg.

2) Verify that the value for "AmbPres" in the Audit Screen is within ±10 mm Hg of the measured ambient pressure. If this is not the case, perform the ambient pressure calibration procedure.

C.3.2.9 Ambient Pressure Calibration

Perform ambient pressure calibration in the following manner:

1) Press <MENU> to enter the Service Menu. With the cursor pointing to "Calibration/Audit" press <F3: SensCal> to enter the Sensor Calibration Screen.

2) Determine the current ambient pressure in millimeters of Hg.

3) Press <Edit> and enter the measured ambient pressure in the "Actual" column of the "Amb Pres" row of the Sensor Calibration Screen and press <Enter>. The sampler automatically adjusts the corresponding offset. Write down this offset number in the logbook.

C.3.2.10 Flow Verification

Flow verification must be done before disturbing any seals. Perform the flow verification procedure below in the following manner:

1) Insert a filter cassette containing a new 47-mm filter in the topmost position of the filter cassette supply magazine.

2) Press <Menu> to display the Master Menu.

3) Press <F1:LeakChk> to display the Leak Check screen.

4) Press <F4:FiltAdv> to advance the filter and place the filter from the magazine into the sample position. Wait for filter change to complete.

5) If you are using the Streamline FTS Flow Transfer Standard to verify the flow of the Partisol®-Plus Sampler, confirm that the FTS calibration constants *m* and *b* are entered in the Audit Screen.

6) Remove the sample inlet from the external sample tube of the Partisol®-Plus Sampler.

7) Attach the Streamline FTS Flow Transfer Standard to the sample tube. Other flow meters may require the use of the Flow Audit Adapter, which should be installed with its valve open.

8) Press <F2: Start>. After the prompt, press <F3: Valve>.

9) Select "Set Flow" in the Audit Screen and press <Edit>.

10) It is recommended that the set point be the regular operational flow, which is usually 16.7 L/min. Ensure that the flow rate, as displayed in the "Cur" (current) column stabilizes close to the entered set point (± 4%). If not, perform the flow calibration procedures.

11) If using the FTS Streamline Flow Transfer Standard to measure flow, press <Edit>, then enter the measured flow transfer standard pressure (in water) in the "FTS Pres" column. The Partisol®-Plus will calculate the flow and display the result in the "FTS Flow" field (L/min). If using another flow measurement device, determine the measured flow rate in liters per minute. Compare the measured flow with the current flow displayed in the Audit Screen.

12) Verify that the current flow is within ± 4% of the measured flow. If this is not the case, perform the flow calibration procedure.

13) If the verification procedure is complete, reinstall the First Stage Inlet.

C.3.2.11 External Leak Check

Perform a system leak check in the manner described below. In addition to the required leak checks, a leak check must also be performed anytime when a seal in the sampler is disturbed.

NOTE: To ensure there are no leaks, a filter cassette containing a new 47-mm filter must be installed in the sampling position of the sampler.

If a filter change was not done in the first step of the verification procedure, follow steps 1-4 below to move a filter into the sampling position**.**

NOTE: If the leak checks or flow verification are being performed while the sampler is in the **Sampling** mode, remove the storage magazine which may contain previously sampled filters and replace it with a clean storage magazine before advancing the partially sampled filter to the storage magazine. Carefully remove the sampling filter cassette from the storage magazine after step 3 below and reinstall it in the topmost position of the supply magazine so that this filter will be moved back into the sampling position to complete the sampling run after the verification or maintenance is complete. The sampler will begin the sampling run after the sampling cassette is in the correct position.

1) Insert a filter cassette containing a new 47-mm filter in the topmost position of the filter cassette supply tube.

2) Scroll to “LeakChk” then press <ENTER> to display the Leak Check Screen. Press <F4:FiltAdv>. Wait for filter change to complete.

3) Remove the sample inlet from the external sample tube.

4) Install the flow audit adapter on the end of the tube.

5) Close the valve on the flow audit adapter.

6) Press <F2: Start>. After the prompt, press <F1: Externl> to select the external leak check.

7) Follow instructions displayed on screen.

8) The sampler will automatically pull vacuum and check for flow.

9) A pass or a fail message will be displayed at the end of the leak check cycle. A pressure drop of 25 mm Hg/min or less is the sampler’s leak check pass criteria.

10) If a leak check fail message is displayed on the screen, insert a new filter cassette containing a new 47-mm filter in the topmost position of the filter cassette supply tube and repeat the leak check procedure.

11) If the leak check fails again, attempt to find the leak and repair it. If you are unable to locate the source of leak, contact the Monitoring, Modeling, and Emissions Inventory Coordinator at the DEQ State Office.

12) If the leak check passes, slowly open the valve on the flow audit adapter.

13) If performing a flow verification immediately, retain the filter cassette with 47 mm filter in the sampling position.

14) Otherwise, remove the flow audit adapter from the external sample tube and reinstall the sample inlet previously removed.

C.3.2.12 Internal Leak Check

Perform an internal leak test of the Partisol®-Plus Sampler in the manner described below.

NOTE: To ensure that there are no leaks, a filter cassette containing a 47-mm leak check metal disk must be installed in the hardware.

1) Insert a filter cassette containing a leak check disk (the screen should be removed before installing the leak check disk) in the topmost position of the filter cassette supply tube. Insert the supply magazine into the sampler.

2) In the Leak Check Screen, press <F4: FiltAdv> to move the leak check cassette into the sampling position. Wait for filter change to complete.

3) Remove the sample inlet from the external sample tube.

4) Press <F2: Start>. Press <F2: Internl> to select the internal leak check. Follow the instructions on the display to complete the leak check.

5) The Partisol®-Plus sampler will run an automatic leak check and report either a pass or fail message. A pressure drop of 140 mm Hg/min or less is the sampler's leak check pass criteria.

6) Press <F4: FiltAdv> to move the leak check cassette to the storage magazine.

7) If a failure message is displayed, clean the cassette and leak check disk carefully. Examine the cassette and disk for any external nicks or scratches. Discard any damaged cassette or disk, and re-run the test with a clean, undamaged cassette and leak check disk.

8) If leak check fails again, attempt to find the leak and repair it. If you are unable to locate the source of leak, contact the manufacture for assistance.

9) If a pass message is displayed replace the first stage inlet.

NOTE: If the verification is being performed while the sampler is in the **Sampling** mode, ensure that the partially sampled filter is reinstalled in the topmost position of the supply magazine, so that the sampling run will be completed on the correct sampling filter.

C.3.2.13 Flow Calibration

Perform the temperature calibration, pressure calibration, and leak check described above before executing the flow calibration procedure below.

NOTE: Ensure that the filter cassette previously installed in the sampler to perform the above leak check remains in the unit for the flow verification.

Calibrate the flow in the following manner:

1) If you are using the Streamline FTS Flow Transfer Standard to verify the flow of the Partisol®-Plus Sampler, confirm that the FTS calibration constants *m* and *b* are entered in the Audit Screen.

2) Remove the sample inlet from the external sample tube of the Partisol®-Plus Sampler.

3) Attach the Streamline FTS Flow Transfer Standard to the sample tube. Other flow meters may require the use of the flow audit adapter, which should be installed with its valve open.

4) Press <Edit> and enter the desired minimum and maximum calibration flow rates ("Min. Flow" and "Max. Flow"). It is recommended to use 15.0 L/min for the minimum flow rate and 18.4 L/min for the maximum flow rate. These values are 10% below and 10% above 16.7 L/min, respectively.

5) Under "Num Points" enter "3" for three calibration points.

6) Press <F9: Start> to initiate the flow calibration.

7) Wait for the flow to stabilize, then press <Edit> and enter either the pressure drop (inches water) from the Streamline FTS in the "Pressure" field or the flow (L/min) from a flow meter in the "Act Flow" field. Then press <Enter>.

8) The sampler automatically adjusts the offset and span values in the Flow Calibration Screen once it performs measurements at all flow rate plateaus.

C.3.3 Sampler Calibration Frequency

To ensure accurate measurement of the PM$_{2.5}$ concentrations, calibrate PM$_{2.5}$ samplers upon receipt. Tables C.3.1, C.3.2, and C.3.3 below summarize the calibration, verification, and maintenance frequencies. Tables C.3.2 and C.3.3 are to be used for quality control purpose and kept on site. The sampler also needs to be calibrated after any electro-mechanical repairs that might affect sampler calibration and if the sampler is transported.

Table C.3.1

Calibration and Verification Check Intervals

Parameter	Recommended interval
Single point flow rate verification	Every four weeks
Flow rate multi-point verification	On installation, then annually or when one point fails
Flow rate calibration	If multi-point verification failure
Temperature verification (single point: ambient air inlet sensor and filter temperature sensor)	Every four weeks
Temperature multi-point calibration	On installation, then annually
Temperature calibration (multi-point)	If multi-point verification failure
Pressure verification	Every four weeks
Pressure calibration	On installation, then annually or if out of specification

Table C.3.2

PM$_{2.5}$ Sampler Quarterly Performance and Maintenance Check Sheet

Parameter	**Frequency**	**Initial and date boxes after each check is completed**																		**Nominal Value**
External Leak Check	Every 5 Sampling Events																			80 ml/min
Internal Leak Check	Annually and After Major Maintenance																			80 ml/min
One-point Temperature Verification	Once every 4 weeks																			± 4^{o}C of Standard
Water Collector Bottle Inspection	Every 5 Sampling Events																			
Impactor Well Cleaning and Oiling	Every 5 Sampling Events																			

Table C.3.3

PM$_{2.5}$ Sampler Annual Performance and Maintenance Check Sheet

	Frequency	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Acceptance Criteria
One Point Flow Rate Verification	Once every 4 weeks													± 4% of the Transfer Standard
Flow Rate Multi-point Verification	1/Year or if One Point Failure													± 4% of the Transfer Standard
Flow Rate Calibration	If Multi-Point Failure													± 4% of the Transfer Standard
Temperature Multi-point Verification	1/Year													± 2°C of Standard
Temperature Calibration	If Multi-Point Failure													± 2°C of Standard
Pressure Verification	Once every 4 weeks													± 10 mm Hg
Pressure Calibration	1/Year													± 10 mm Hg
Clock/Timer Verification	Once every 4 weeks													1 min/month
Disassemble, Inspect, and Clean Sample Inlet	Once every 4 weeks													
Clean Interior of Sample Case	Once every 4 weeks													

C.4 FIELD OPERATIONS

This section presents information pertinent to the routine operation of a PM$_{2.5}$ monitoring site. It covers an array of topics, ranging from initial site selection to final data documentation.

C.4.1 Siting Requirements

The following siting requirements must be met, depending upon the site scale employed.

Each monitor operated by DEQ is assigned a scale of representativeness based on the definitions of 40 CFR Part 58, Appendix D.

Micro Scale - describes air volumes associated with area dimensions ranging from several meters up to about 100 meters (m).

Middle Scale - describes air volumes associated with area dimensions up to several city blocks in size with dimensions ranging from about 100 m to 500 m (0.5 kilometer [km]).

Neighborhood Scale - describes air volumes associated with an area of a city that has relatively uniform land use with dimensions in the 500 m to 4,000 m (0.5 to 4.0 km) range.

Urban Scale - describes air volumes within cities with dimensions on the order of 4,000 m to 50,000 m (4.0 km to 50 km). This scale would usually require more than one site for definitions.

Regional Scale - describes air volumes associated with rural areas of reasonably homogeneous geography that extends for tens to hundreds of kilometers.

C.4.1.1 Probe Height

Although micro scale or middle scale stations are not the preferred spatial scale for PM$_{2.5}$ sites, there are situations where such sites are representative of several locations within an area where large segments of the population may live or work. In these cases, the following probe height requirements for each scale must be adhered to.

C.4.1.1.1 Micro Scale

The sampler inlet for micro scale PM$_{2.5}$ monitors must be 2-7 meters above ground level.

C.4.1.1.2 Middle or larger Scale

The required height of the air intake for middle, or larger scale PM$_{2.5}$ monitors is 2-15 meters above ground level.

C.4.1.2 Horizontal Spacing from Obstructions

The sampler may be located on a roof or other structure, but must be a minimum of 2 meters from walls, parapets, penthouses etc. No furnace or incineration flues should be nearby. The separation distance from a flue is dependent on the height of the flue, type of waste or fuel burned, and quality of the fuel (ash content). In the case of emissions from a chimney resulting from natural gas combustion, as a precautionary measure, the sampler should be placed at least 5 meters from the chimney. On the other hand, if fuel oil, coal, or solid waste is burned and the stack is sufficiently short so that the plume could reasonably be expected to impact on the sampler intake a significant part of the time, other buildings/locations in the area that are free from these types of sources should be considered for sampling.

Trees provide surfaces for particulate deposition and also restrict airflow. Consequently, trees should be carefully evaluated concerning their impact on the sampler prior to placing the sampler in the vicinity of the tree. Consideration must be given to the fact that the trees, shrubs, and other vegetation will grow, increasing their impact on the airflow, and airborne particulate concentrations.

C.4.1.2.1 Micro Scale

- Preferably, the sampler should be placed at least 20 meters from a tree's dripline, but it must be no closer than 10 meters from the dripline even when the tree(s) acts as an obstruction.

- The sampler must be located away from obstacles such as buildings and trees that act as an obstruction, so that the horizontal distance between the obstacles and the sampler is at least twice the height that the obstacle protrudes above the sampler. For example, if the obstacle protrudes 15 meters above the sampler then the distance between the obstacle and the sampler must be at least 30 meters.

- The horizontal spacing criteria for structures that protrude above the probe height do not apply for street canyon sites, due to the close proximity of the adjacent structures. The intent of these street canyon sites is to measure the maximum concentrations from a road or point source. Consequently, there must be no significant obstruction between the road or point source and the probe location., even though other spacing from obstruction criteria are met.

- There must be an unrestricted airflow in an arc of at least 270° around the sampler except for street canyon sites. The predominant direction for the season with the greatest pollutant concentration potential must be included in the 270° arc.

C.4.1.2.2 Middle Scale

- Preferably, the sampler should be placed at least 20 meters from a tree's dripline, but it must be no closer than 10 meters from the dripline even when the tree(s) acts as an obstruction.

- The sampler must also be located away from obstacles such as buildings, so that the distance between obstacles and the sampler is at least twice the height that the obstacle protrudes above the sampler.

- Sampling stations that are located closer to obstacles than this criterion allows should not be classified as neighborhood, urban, or regional scale, since the measurements from such a station would closely represent middle scale stations. Therefore, stations not meeting the criterion should be classified as middle scale.

- There must be unrestricted airflow in an arc of at least 270° around the sampler site.

C.4.1.2.3 Neighborhood, Urban, or Regional Scale

- Any station, 2 to 15 meters high, and further back than the middle scale requirements will generally be neighborhood, urban or regional scale.

C.4.1.2.4 Default Scale

Stations not meeting these criteria may be classified as micro scale.

C.4.1.3 Spacing from Roads

The following criteria must be applied as the siting criteria for sequential sampler probe locations with respect to roadways adjacent to the monitoring sites.

It is important to note that the separation distances shown in Figure C.4.1 are measured from the edge of the nearest traffic lane of the roadway presumed to have the most influence on the site. In general, this presumption is an oversimplification of the usual urban settings which normally have several streets that impact a given site. The effects of surrounding streets, wind speed, wind direction and topography should be considered along with Figure 2 before a final decision is made on the most appropriate spatial scale assigned to the sampling

C.4.1.3.1 Micro Scale

For micro scale stations, the sampler must be between 5 and 15 meters from a major roadway. For a street canyon site, the location must be between 2 and 10 meters from the roadway.

C.4.1.3.2 Middle Scale and Neighborhood Scale

Figure C.4.1 provides guidance on the recommended monitoring distances from the paved roads with different levels of average daily traffic.

For the middle scale station, a range of acceptable distances from the roadway is shown in Figure C.4.1. This figure also includes separation distances between a roadway and neighborhood or larger scale stations by default. For example, according to Figure C.4.1, if a PM sampler is primarily influenced by roadway emissions and that sampler is set back 10 meters from a 30,000 Average Daily Traffic (ADT) road, the station should be classified as a micro scale, if the sampler height is between 2 and 7 meters. If the sampler height is between 7 and 15 meters, the station should be classified as middle scale. If the sample is 20 meters from the same road, it will be classified as middle scale; if 40 meters, neighborhood scale; and if 110 meters, an urban scale.

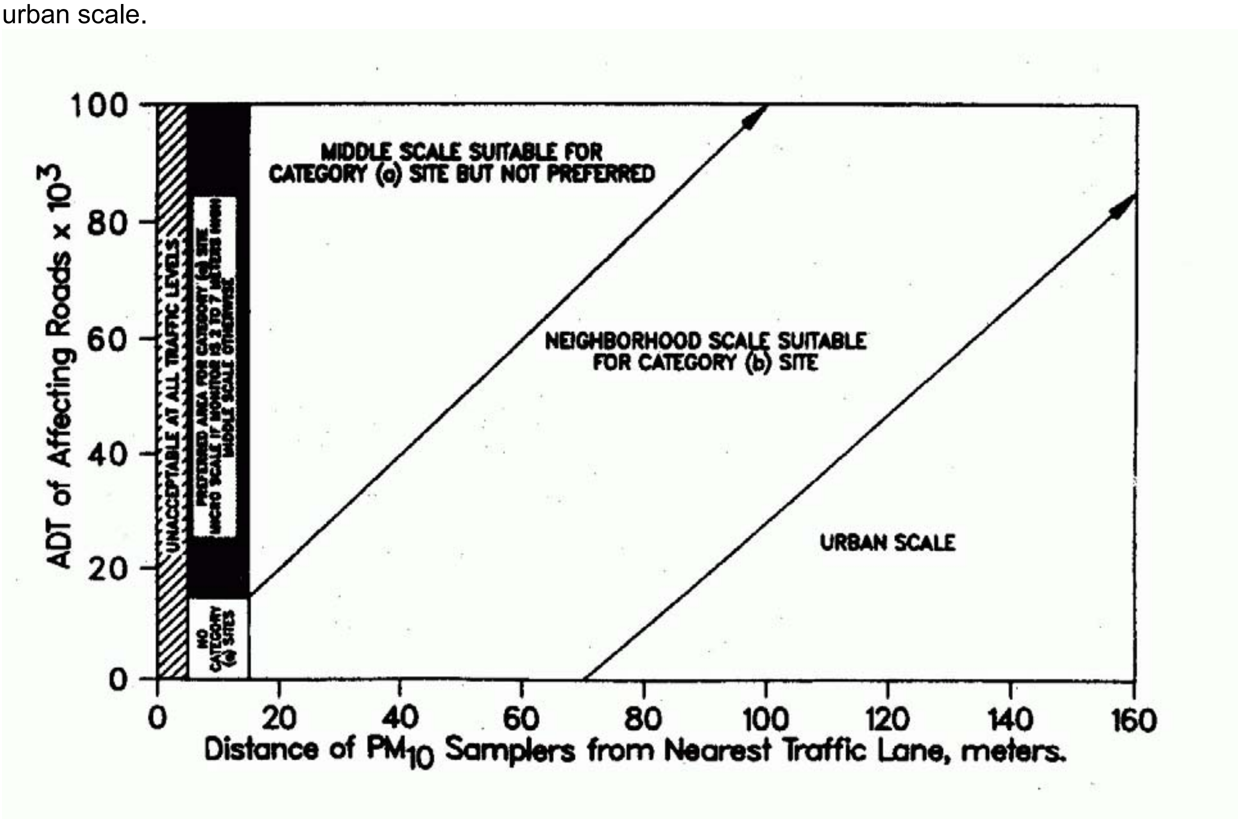

Figure C.4.1 Particulate Sampler's Horizontal Distance to Nearest Traffic Lane Except for Micro Scale Street Canyon Sites.

C.4.1.4 Spacing from Nearby Sources and other Considerations

- Stations should not be located in an unpaved area unless there is vegetative ground cover year-round.
- In case of emissions from a chimney resulting from natural gas combustion, the sampler should be placed at least 5 meters from the chimney.
- Monitors should not be located within 100 meters of residential wood burning appliances.

C.4.1.5 Other Requirements

Table C.4.1 presents the minimum siting criteria for the placement of the PM$_{2.5}$ sampler. This is not a complete listing of siting requirements. Instead, it should be used as an outline to determine a sampler's optimum location. Complete siting criteria are presented in 40 CFR Part 58, Appendix E.

Several additional factors must also be considered in determining where the sampler will be deployed. These include accessibility under all weather conditions, availability of adequate stable power, security of the equipment, and safety of the monitoring personnel. The site should be able to provide sufficient power for the primary sampler, a collocated sampler, and an Federal Reference Method (FRM) performance evaluation sampler.

The sampler must be situated where the operator can reach it safely despite adverse weather conditions. If the sampler is located on a rooftop, care should be taken that the operator's personal safety is not jeopardized by a slippery roof surface during inclement weather. Consideration also should be given to the fact that routine operations (i.e., calibrations, filter installation and recovery, flow checks, and audits) involve transporting supplies and equipment to and from the monitoring site.

The security of the sampler itself depends mostly on its location. Rooftop sites with locked access and ground-level sites with fences are common. The security of the operating personnel, as well as that of the sampler, must always be considered.

Table C.4.1

Minimum PM$_{2.5}$ Sampler Siting Criteria

Scale	Height Above Ground (Meters)	Vertical and Horizontal Distance from Supporting Structure (Meters)	Other Spacing Criteria
Micro	2 to 7	>2	Should be >20 meters from trees.
Middle, neighborhood, urban, and regional	2 to 15	>2	Distance from sampler to obstacle, such as a building, must be twice the height that the obstacle protrudes above the sampler.
			Must have unrestricted airflow 270° around the sampler inlet.
			Sampler is maintained in a horizontal plane and is 2.0±0.2 meters above the floor or horizontal surface.
			Sampler inlet is at least 2 meters but not greater than 4 meters from any collocated PM$_{10}$ sampler. (See 40 CFR Part 58, Appendix A.)

C.4.2 Sampler Installation

1) Upon receipt of a PM$_{2.5}$ sampler, visually inspect it to ensure that all components are accounted for. Notify the laboratory immediately of any missing or damaged equipment.

2) Carefully transport the sampler to the field site. Secure the PM$_{2.5}$ sampler in its location, keeping it level.

3) Install the sampler inlet on the base unit and check all tubing and power cords for crimps, cracks, or breaks

4) Turn on the sampler and perform a leak test with a filter in the filter cassette.

5) Allow the sampler to run and equilibrate with ambient conditions for about 15 minutes. Calibrate the sampler as discussed in the Section C.3.

6) Fill out the initial calibration form shown in Table 4.2.

Table 4.2

Initial Calibration Form

Partisol-Plus Model 2025 Sequential Air Sampler Calibration Sheet

Sampler Serial Number	Impactor Serial Number

Instrument Calibration Constant Values:

Screen	Assignment	Offset	Span
Sensor Calibration	Amb Temp: Amb Pres:		
Filter Temp Calibration	Filter:		
Filter Compartment Calibration	Filter Comp:		
Flow Calibration	Flow Calib:		

Software Version: _______ Software Update _______
Signature _______ Date _______

C.4.3 Sampling Operations

This section discusses the steps necessary to prepare for and to complete a sampler run.

1) Fill out top portion of run data sheet with information related to the sample collection such as site location or identification number, date and time of sampler setup visit, sample start date, filter identification, and cassette identification number. The run data sheet is shown in Table C.4.2. This will also be the chain of custody sheet. The number of run data sheets will correspond to the number of filters in the magazine.

2) Ensure that the sampler is not operating and that there is enough time available to complete setup procedures before its automatic start.

3) Open the filter holder assembly and install the filter magazine containing preweighed filters. Do not remove the filters from the cassette. Install the filter cassette magazine into the sampler on the left side and a clean magazine on the right side.

4) In the Main Screen Press <F3: FiltSet>and then press <F4:FiltLst> to display the filter list.

5) Press <EDIT>, then enter the filter identification numbers and press <ENTER>.

6) Press the < →> arrow to move the cursor to the Cassette identification field and Press <EDIT>, then enter in the cassette identification number in this field and press <ENTER>.

7) Make sure filter identification numbers are entered in the same order as they are stored in the filter magazine.

8) If the filter cassette magazine has a blank filter, after entering the filter identification number and cassette identification number, press the side arrow key < →> to move the cursor on the screen to blank field. Pressing F1<-List> or F2 <+List>will let the operator select YES or NO options to denote if the filter is a blank or not.

9) Program the sampler for midnight to midnight continuous sampling:

a) Set the sampler in the **Stop** mode to enter a sampling program

Table C.4.3

Example of a Sampler Run Data Sheet

~~IDEQ PM $_{2.5}$ SAMPLE REPORT/FILTER HISTORY~~

~~Field Data~~

Date/Time of Recovery: ________________________

Site Airs ID: Filter ID:

Site Name: _______________________

Sampler Run Date:

Operator (on/off): ___________________

Questionable Sample (if checked, explain in comments section)

~~Run Data~~

KEY	DESCRIPTION	VALUE	PARAM	POC	INT	UNITS	METHOD	FREQ	DECIMAL
1	Flow CV, %		**68101**	**1**	**7**	**107**	**117**	**3**	**1**
2	Flag Code, Flow Rate			**1**	**7**			**3**	
3	Sample Volume, m^3		**68102**	**1**	**7**	**65**	**117**	**3**	**1**
4	Min.Ambient Temp, ^{o}C		**68103**	**1**	**7**	**17**	**117**	**3**	**1**
5	Max.Ambient Temp		**68104**	**1**	**7**	**17**	**117**	**3**	**1**
6	Ave.Ambient Temp, ^{o}C		**68105**	**1**	**7**	**17**	**117**	**3**	**1**
7	Min.Ambient Press, mm		**68106**	**1**	**7**	**59**	**117**	**3**	**1**
8	Max.Ambient Press		**68107**	**1**	**7**	**59**	**117**	**3**	**1**
9	Ave. Ambient Press		**68108**	**1**	**7**	**59**	**117**	**3**	**1**
10	Flag Code, Temp Diff.			**1**	**7**			**3**	**1**
11	Run Start Time			**1**	**7**			**3**	
12	Elapsed time, HH:MM		**68109**	**1**	**7**	**106**	**117**	**3**	
13	Flag Code, Run Time, Y			**1**	**7**			**3**	
14	Calc Concentration		**88101**	**1**	**7**	**105**	**117**	**3**	**1**

~~Filter History Data~~

Action	Date	Time	Filter Temp. ^{o}C		Initials/Comments		
Initial Weight by Lab							
Received From lab							
Retrieved from Sampler							
Stored in Freezer							
Shipped to Lab							
Received by Lab							
Start Conditioning							

~~Laboratory Data~~

Filter ID:__________ Initial Weight, mg:_________ Final Weight, mg:_________ Net Weight, mg:_________

Calculated Concentration, ug/m^3: Analyst: _________ Reviewed by: ___________

Questionable Sample (if checked, explain in comments section)

~~Comments~~

____

____

____

b) Press <ESC> twice to get to Main Menu. Press <F5: SETUP>.

c) Press <EDIT> to set up default sample repeat time. For samplers running on the 1/1 schedule, enter 24:00 and press <ENTER>. For samplers running on 1/3 schedule, enter 72:00 and press <ENTER>. For collocated samplers running on the 1/6 schedule, enter 144:00 and press <ENTER>.

10) The sampler is now ready to sample. Inspect the records of the sampler, the Sampler Quarterly Performance and Maintenance Check Sheet (Table C.3.2), and Sampler Annual Performance and Maintenance Check Sheet, (Table C.3.3). Perform any necessary scheduled maintenance, verification, and calibration activities.

11) During the equipment checks required every four weeks, measure and record independent measurements of ambient temperature and pressure and ensure that the ambient inlet temperature and pressure readings taken by the sampler are within 4.0 °C and 10 mm Hg of the independent readings. Also check the sampler's display for the filter temperature and ensure this value is within 5 °C of the ambient temperature display. Keep a record of the activities performed in the logbook.

C.4.4 Post Sampling

1) Return to the monitoring site within 96 hours (4 days) of the end of the sample collection period and carefully remove the filter magazine from the sampler. Place the cover on the filter magazine.

2) Place the filter cassette magazine in a protective covering (polyethylene or polypropylene bag) such that the cover does not come off. Cover the magazine with blue ice and place it in the cooler box. After retrieval, care must be taken to maintain the filter magazine as cool as possible in the cooler and protect it from exposure to temperatures above 4 °C.

3) Check the sampling run status on the Main Screen and note if the status is other than "OK." Press <F4:Data> to view the filter data from the run. Record the total sample time, sampler volume, sample removal date/time, sampler's indicated ambient temperature and barometric pressure, final flow rate, average flow rate, and coefficient of variation of the flow rate on the Sampler Run Data Sheet. If the status codes are other than "OK," verify the validity of the run by pressing <F3:More Dat> until the filter Data Status Codes Screen appears.

4) Make a record of any out of specification flow rate, filter temperature, or elapsed sample time, and if any flags were triggered by the sampler. Note in the record any unusual conditions that may have affected the sample.

5) Install a loaded supply magazine and empty storage magazine and repeat Section C.4.3, steps 1 through 9 for next sampling run.

6) Record any comments or unusual conditions such as sampler tampering or malfunctions, construction activities, fires, or dust storms on the form.

7) Transport the filter magazine and store it in the refrigerator/freezer. Ship the filter magazine and the Sampler Run Data Sheet(s), in protective bag with the filter magazine to the lab. The mailing should be done as soon as possible.

C.4.5 Quality Control Flow Check Procedure

A flow rate verification check of the sampler flow rate is required every four weeks. The procedure for flow rate verification check is described in Section C.3. These flow checks will provide an indication of when flow limits have been exceeded.

Changes in actual flow rate greater than ±4%, as determined by a monthly field flow rate verification check, may cause invalidation of all samples collected since the last acceptable flow rate check. Deviations from the design flow rate greater than ±5% that occur during sampling necessitates that the sample data be flagged for potential invalidation.

1) Record the **actual** flow rate measured by the flow verification check device and the flow rate **indicated** by the sampler in the Field Data Section of the PM$_{2.5}$ Sampler Single-Point Calibration Verification sheet (Table C.4.3)

2) Using the above data, calculate the percentage difference as:

$$\text{QC \% Difference} = \left[\frac{Ind - Act}{Act}\right] \times 100$$

Where: *Ind* represents the sample reported flow value, and

Act indicates the transfer standard reported flow value.

3) If the sampler flow rate is within 96 to 104% of the measured flow rate at actual conditions and if the sampler flow rate is within 95 to 105% of the design flow rate of 16.67 L/min, the sampler is operating properly.

4) If either limit is exceeded, repeat the leak check procedure, as described in Section C.3. Investigate and correct any malfunction and recheck the flow. If necessary, recalibrate before sampling again.

Table C.4.4

PM$_{2.5}$ Sampler Single-Point Calibration Verification

Date:___________ Time:____________ Site ID:__________ Site Name:

Sampler Model:______________________ Sampler Serial Number:

Leak Checks:

External			Internal	
Time	**Indicated Pressure, In. Hg**		**Time**	**Indicated Pressure, In. Hg**

Pass External Check, check if pressure drop is less than 5 inches Hg after 60 seconds
Pass Internal Check, check if pressure drop is less than 8.5 inches Hg after 30 seconds

Single Point Sampler Calibration Verification Checks:

Transfer Standard Information					
Parameter	Type	Serial Number	Slope	Intercept	Certification Date
Temperature					
Pressure					
Flow Rate					

Field Data					
Parameter	Transfer Standard Readings Corrected	Uncorrected	Sampler Readings	Difference (Sampler-Transfer)	% Difference (Diff/TS x 100)
Filter Temp, EC					n/a
Ambient Temp, EC					n/a
Pressure (mm Hg)					n/a
Flow (L/min)					

Maintenance Performed:

Inspect PM$_{10}$ Inlet O-rings (qtrly)
Inspect Bulkhead O-rings (qtrly)
Inspect Tubing/fittings (qtrly)
Change In-line Filter (6 months)
Inspect Lip Seals (each run)
Clean Air Screens (6 months)
Empty Water Jar (5 sample days)
Clean WINS Impactor (5 sample days)
Clean WINS Impactor Jets (monthly)
Check Battery Voltage (6 months)
Check Sampler Clock (monthly)
Clean PM$_{10}$ Inlet (14 samples)
Clean Sample Tube (qtrly)
Inspect WINS O-rings (qtrly)

C.5 LABORATORY ACTIVITIES

The Idaho Bureau of Laboratories Standard Operating Procedure (SOP) for PM$_{2.5}$ FRM Filter Processing for the Division of Environmental Quality (SOP No. 200-5) (IBL 1998) is included in Appendix B of the *Quality Assurance Project Plan for the State of Idaho PM$_{2.5}$ Ambient Air Quality Monitoring Program*. All of the essential elements prescribed by Section 2.12.7 of the EPA *Quality Assurance Document*, Volume II, (April 1998) are contained in SOP No. 200-5.

C.6 CALCULATIONS, VALIDATIONS, AND REPORTING OF PM$_{2.5}$ DATA

This section discusses calculations, validations, and reporting of PM$_{2.5}$ data.

C.6.1 Calculations

PM$_{2.5}$ concentration calculations shall be performed using the following equations.

1) Calculate the total volume of air sampled:

$$V = Q_a \times t \times 10^{-3}$$

Where:

V = total volume of air sampled, m^3

Q_a = average sampler flow rate, l/minute

t = total elapsed sampling time, minutes

10^{-3} = Conversion factor, m^3/L

2) Calculate total PM$_{2.5}$ mass concentration in micrograms per cubic meter:

$$PM_{2.5} = \frac{(M_{gross} - M_{tare})}{V} \times 10^3$$

Where:

PM$_{2.5}$ = PM$_{2.5}$ mass concentration, µg/m^3

M_{gross} = gross (final) weight of filter, mg

M_{tare} = tare (initial) weight of filter, mg

V = total sample volume, m^3

10^3 = conversion factor, µg/mg

C.6.2 Calculation Validation

Data that are needed to compute the mass concentration of PM$_{2.5}$ originate from two main sources: field operations and laboratory operations. Data must be validated to ensure that all reported PM$_{2.5}$ measurements are accurate relative to the overall scope of the quality assurance program. When the final mass concentration of PM$_{2.5}$ in a sample has been computed, the validation procedure will not only check these computations, but will also aid in flagging questionable mass concentrations (i.e., extremely high or low values). Therefore, should a mass concentration approach the primary or secondary ambient air quality standard, this validation procedure will provide checks for all preliminary field and laboratory operations. The steps of the calculation validation procedure are as follows:

1) Gather the following data for each sample.

- Total sampling time (minutes)
- Average actual volumetric flow rate, Qa (l/minute)
- Tare and gross weights, Wt and Wg, of the PM$_{2.5}$ filter (mg)

2) Recalculate the total mass concentration of PM$_{2.5}$ for 7 samples per 100 (minimum of 4 per lot). These suggested frequencies may be adjusted based on accumulated experience and level of data quality. Decrease the frequency if experience indicates that data are of good quality, or increase it if data are of marginal or poor quality.

3) Compare each validated PM$_{2.5}$ concentration with the originally reported value. Correct any errors that are found, initial them and indicate the date of correction. If a high percentage of errors is found, check additional calculated values. If consistent errors are found, check all values in the block of data and investigate and correct the cause.

4) Scan all total mass concentration values; note those that appear excessively high or low and investigate. Repeat Steps 2 and 3 for those samples.

5) If all mass concentration computations appear correct and questionably high or low values still exist, review all raw data (i.e., sample time, average actual volumetric flow rate) for completeness and correctness.

C.6.3 Final Data Validation

Data that have been reviewed by the Modeling, Monitoring, and Emissions Inventory (MMEI) staff, and found to satisfy the requirements (e.g., filter holding times, etc.) of this procedure and the criteria defined in the *Idaho Division of Environmental Quality PM$_{2.5}$ Monitoring Quality Assurance Project Plan* will be certified as valid.

C.6.4 Data Reporting

Data are coded into the telemetry system database from the laboratory reports. After the data are logged and edited, the MMEI staff will prepare quarterly and annual summary reports and transmit the data to EPA.

C.7 MAINTENANCE PROCEDURES

This section presents the regular maintenance schedule that allows the monitoring network to operate for long periods of time without system failure. The operator may find that increasing the routine maintenance frequency is necessary due to the operational demands on the samplers. All maintenance activities are to be documented in the sampler's logbook. Table C.7.1 is a summary of required maintenance procedures and frequencies.

C.7.1 Supplies and Tools Recommended for Maintenance

1) Ammonia-based general purpose cleaner

2) Cotton swabs

3) Small soft-bristle brush

4) Paper towels

5) Distilled water

6) Silicone-based stopcock grease

7) Small screwdriver

8) Small crescent wrench

9) Pocket knife

Table C.7.1

Routine Maintenance Activities

EQUIPMENT	FREQUENCY	ACTION
WINS impactor	Every 5 sampling days	Service WINS impactor
Water collector jar	Every 5 sampling days	Clean
Tubing and fittings	Every 5 sampling days	Replace as necessary
Upper and lower collector assembly	Monthly	Clean
Inlet O-rings	Monthly	Inspect, replace if damaged
Inlet O-rings	Quarterly	Remove, inspect, and lightly coat with vacuum grease
Sampler down tube	Quarterly	Clean
Down tube water seal gasket	Quarterly	Inspect and replace if necessary
WINS impactor gasket and O-rings	Quarterly	Inspect, lubricate, and replace if necessary
Air intake and fan	Quarterly	Clean
Vacuum motor	As needed	Replace if needed
Power lines	Inspect on sample-recovery days	Replace as necessary

C.7.2 Recommended On-Hand Spare Parts

1) Gaskets

2) O-rings

3) Batteries

4) Anything else that might wear out

C.7.3 Exchanging Particle Trap Filters

The particle trap filters are located behind the filter exchange assembly. Perform the procedure below to exchange the particle trap filters.

1) Turn off the sampler.

2) Locate the bowl-style filter behind the filter exchange assembly. Remove the filter bowl by unscrewing it from the filter manifold.

3) Carefully remove the filter stand by unscrewing it from the filter. The O-ring usually remains in the filter manifold.

4) Remove the gasket and top disk from the filter stand. The gasket might sometimes remain inside the filter manifold.

5) Remove the filter element from the filter stand and install a new element.

6) Install the top disk and gasket if necessary into the filter stand.

7) Install the filter stand into the filter manifold. Install the O-ring into the filter manifold, if necessary.

8) Install the filter bowl into the filter manifold.

9) Turn on the sampler and perform a system leak check.

C.7.4 Testing and Exchanging Batteries

The three alkaline AA batteries in the electronics provide backup power for internal data storage and the clock/calendar. The expected lifetime of the batteries in the instrument is one year.

NOTE: Always wear appropriate anti-static devices when working with the system electronics.

Follow the steps below to ascertain if the batteries need replacing and to exchange if necessary. Perform this function quarterly.

1) Remove the three screws securing the pump compartment cover, slide the cover up, and remove.

2) Open the electronics compartment of the sampling unit and locate the batteries.

3) Check whether the batteries need replacing by measuring the voltage across the test point labeled “BATT” (red) on the interface board and the ground test point labeled “188_PGND.” If the measured voltage is less than 4.2 VDC (volts direct current), the batteries need replacing. Skip to step 6 if the voltage is acceptable.

4) Remove the clip that holds batteries in their mounting and pull the old batteries out and replace them with three new ones, noting the proper polarity. Perform this exchange within an elapsed time of five minutes to avoid the loss of data stored in the battery-backed random access memory (RAM).

5) Reinstall the clips to hold the batteries in position. Test for a voltage of 4.2 VDC as in step 4.

6) Close the electronics compartment of the sampling unit.

C.7.5 Maintaining the First Stage, Inlet, and Associated Sub-Assemblies

C.7.5.1 Cleaning the First Stage and Inlets

Cleaning and maintaining the inlet involves its removal, cleaning, and an O-ring check. Although most of the contamination in the inlet is found on the collector plate, the entire inlet must be serviced at least monthly. The following procedure describes how to clean the inlet.

C.7.5.2 Removing and Disassembling the Inlet

1) To remove the inlet, gently lift the complete inlet upward off the 1.25-inch outside diameter (OD) sample tube.

2) Disassemble the upper and lower inlet halves by unscrewing the top acceleration assembly (counter-clockwise) from the lower collector assembly.

C.7.5.3 Maintenance of the Top Acceleration Assembly

1) Mark the top plate deflector cone and lower plate with a pencil scribe to facilitate proper orientation for easier reassembly after cleaning and maintenance.

2) Using a Phillips head screwdriver, remove the four pan head screws from the top of the top plate and lift the top plate off the four threaded spacer standoffs and set aside.

3) Inspect the insect screen for contamination and clean by lifting the screen off the lower plate rain deflector and brush or rinse with water until clean. Dry and reinstall.

4) Using a general purpose cleaner and paper towel, clean the top plate deflector cone and internal wall surface of the acceleration assembly.

5) Inspect the large diameter impactor nozzle O-ring for wear. Replace, if necessary, or using a light coating of silicone grease, apply a thin film on the O-ring itself and a light coating on the aluminum threads of the acceleration assembly.

6) After reinstalling the insect screen, align the top plate markings with the lower plate markings. The four holes in the top plate should align with the four spacer standoffs. Insert the four pan-head screws and tighten securely.

C.7.5.4 Maintenance of the Lower Collector Assembly

1) Using a general purpose cleaner with a paper towel, clean the collector assembly walls and three vent tubes. A cotton swab may be necessary to clean these vent tubes. Likewise, clean the bottom side of the collector assembly.

2) Using a cotton swab, clean the weep hole in the collector plate where the moisture runs out to the moisture trap. Remove the rain jar and clean. Inspect the brass nipple fitting to ensure tightness and non-blockage. When reinstalling the rain jar, place a light coating of silicone grease on the gasket inside the cap of the jar. This will ensure a leak-free fit.

3) Inspect the two inlet-to-inlet tube sealing O-rings for wear. Replace, if necessary. Use a light coating of silicone grease on these O-rings to ensure that a seal is made when reinstalled on the 1.25-inch OD sample tube.

C.7.5.5 Reassembly and Reinstallation of Inlet

1) Reassemble the top and bottom inlet assemblies until the threads tighten. Hand-tighten only.

2) Carefully place the inlet back on top of the 1.25-inch OD sample tube. Take care not to damage the internal O-rings.

C.7.6 Maintenance of the WINS Impactor

The procedure below describes the removal, cleaning, and reinstallation process for the WINS impactor. Clean the WINS impactor in a laboratory or workroom.

C.7.6.1 Removal of the WINS Impactor

1) If the sampler is currently in the **Wait**, **Sampling**, or **Done Operating** mode press <RUN/STOP> and select "Audit" to enter the **Audit Operating** mode. This suspends normal system operations during the exchange of the WINS impactor.

NOTE: No action is required in this step if the sampler is in the **Stop** or **Error Operating** mode.

2) Unlatch and open the top cover of the sampler with the down tube and first-stage inlet attached to gain access to the WINS impactor.

3) Lift the WINS impactor out of the upper part of the sampler enclosure. The WINS impactor is connected on its topside to an adapter that makes contact with the external down tube. Separate the WINS impactor from the adapter.

C.7.6.2 Cleaning the WINS Impactor

1) Unscrew the middle section of the WINS impactor to separate the top piece from the bottom.

2) Remove the impactor assembly from the bottom section of the impactor.

3) With a dry paper towel, wipe off the inside surfaces of the impactor. A general purpose cleaner can be used if necessary.

4) Inspect the O-rings in the top and bottom sections of the impactor for damage and replace if necessary. Place a thin coating of O-ring lubricant, such as silicone grease, onto the O-rings if necessary.

5) Remove the top of the impactor assembly by lifting upward.

6) Remove the filter and clean the top and bottom of the impactor assembly using a dry paper towel. A general purpose cleaner can be used if necessary.

7) Inspect the O-ring in the top section of the impactor assembly for damage and replace if necessary. Place a thin coating of O-ring lubricant, such as silicone grease, onto the O-ring, if necessary.

8) Place a new 37-mm borosilicate glass fiber filter onto the bottom of the impactor assembly to entrap the particles larger than 2.5 μm in aerodynamic dimeter.

9) Place 42 to 44 drops of impactor oil onto the filter to enhance the capture of these larger particles.

10) Place the top of the impactor onto the bottom of the impactor assembly.

11) Place the impactor assembly into the bottom section of the impactor.

12) Screw the top of the impactor back onto the bottom section. Ensure that the WINS impactor remains upright so that the oil in the impactor assembly does not spill.

C.7.7 Cleaning Air Intake Filters

The two air intake filters–one in the filter compartment and one in the pump compartment–should be cleaned at least every six months and more frequently in highly contaminated areas.

1) Locate the two air intake fans. Each of these has an associated air intake filter.

2) Snap off the covers enclosing the air intake filters.

3) Take out the filters and clean them with a brush or wash them with a mild soap solution and water.

4) If the filters were washed in the liquid solution, shake the filters and allow them to dry.

5) Reinstall the filters in their holders and remount the covers.

C.7.8 Inspect "V" Seals

1) Ensure the instrument is in the **Stop** mode.

2) Enter **Service** mode

3) Set the pointer to "Manual Motion Tests" on the Service Menu and press <F4:FiltChg> to go to the Filter Exchange Screen.

4) On the Filter Exchange Screen, turn on the pump (labeled "Pump"), turn on the pressure vent valve (labeled "Pressure"), and turn on the lift/push valve (labeled "LiftPush"). This will cause the lift/push cylinder (middle cylinder on the filter exchange assembly) to retract and will help ease disassembly.

5) Unlatch and open the top cover of the Partisol®-Plus Sampler with the down tube and first-stage inlet end attached to gain access to the WINS impactor.

6) Lift the WINS impactor out of the upper part of the sampler enclosure and locate the down tube mount on the top cover.

7) While supporting the ring on the underside of the top cover, remove the four screws that secure the down tube mount to the top cover. Remove the down tube mount and ring.

8) Locate the down tube mount "V" seal. Examine the seal for drying and/or cracking. Replace, if necessary.

9) Replace the down tube mount and ring onto the top cover ensuring that the side of the ring with the chamber is facing down (towards the WINS impactor and the inside of the enclosure).

10) Locate the top head mounting plate.

11) Remove the four thumbscrews that secure the top head mounting plate to the filter exchange assembly. Lift the plate and remove from the enclosure.

12) Locate the two "V" seals now exposed. The top seal is located in the top head. The bottom seal is located in the now exposed section of the filter exchange assembly. Examine both seals for drying/cracking. Replace, if necessary.

13) Locate the exit cylinder. Remove the three screws that secure the exit cylinder base to the filter exchange assembly. Remove the assembly from the enclosure.

14) Locate the exit cylinder "V" seal and examine the seal for drying/cracking. Replace, if necessary.

15) Place the exit cylinder base in its proper position on the filter exchange assemble and secure using the three screws. Replace the top head mounting plate and secure using the four thumbscrews. Replace the WINS impactor and close the top cover.

16) On the Filter Exchange Screen, turn off the lift/push valve, turn off the pressure vent valve, and turn off the pump.

17) Perform both external and internal leak tests according to the procedure defined in this equipment's operations manual.

18) Resume normal operation.

C.7.9 Other Maintenance

Wipe down the interior of the sampler's case quarterly. This operation will remove insects, dirt, and water deposits that may have collected. This maintenance activity may be required monthly during spring, summer, and autumn months. Inspect the cooling air intake filter during the spring, summer, and autumn months. Clean the cooling air intake filter if necessary.

APPENDIX D: CARBON MONOXIDE ANALYZERS

STATE OF IDAHO

DEPARTMENT OF ENVIRONMENTAL QUALITY

AIR MONITORING QUALITY ASSURANCE

STANDARD OPERATING PROCEDURES

FOR

AIR QUALITY MONITORING

TECO MODEL 48C CARBON MONOXIDE ANALYZER

AND API MODEL 300 CARBON MONOXIDE ANALYZER

MODELING, MONITORING, AND EMISSIONS INVENTORY

JULY 202

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TECO MODEL 48C AND API MODEL 300 CARBON MONOXIDE ANALYZERS

* API is a subsidiary of Teledyne Technologies

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TECO MODEL 48C AND API MODEL 300 CARBON MONOXIDE ANALYZERS

ACRONYMS, UNITS, AND CHEMICAL NOMENCLATURE

API	Advanced Pollution Instrumentation
CO	carbon monoxide
ccm	cubic centimeters per minute
DAS	data acquisition system
ESD	electrostatic discharge
FEP	fluorinated ethylene propylene
IR	Infrared
kHz	kilo-Hertz
mV	Milli-volts
MFC	mass flow controller
NIST-SRM	National Institute of Standards and Technology – Standard Reference Method
PCA	printed circuit assembly
ppm	parts per million
sccm	standard cubic centimeters per minute
slpm	standard liters per minute
SOP	standard operating procedure
TECO	Thermo Electron Corporation
VAC	voltage – alternating current

TECO MODEL 48C AND API MODE 300 CARBON MONOXIDE ANALYZERS

This standard operating procedure (SOP) references two different manufacturer's operating manuals for carbon monoxide (CO) analyzers. One model is a Thermo Electron Corporation (TECO) Model 48C Gas Filter Correlation CO analyzer. This SOP references the 2001 instruction manual for the TECO Model 48C. The other model is the Advanced Pollution Instrumentation (API) Model 300 GFC CO Analyzer. This SOP references the 1997 instruction manual for the API Model 300. This document combines each of these model's instruction manuals into one general SOP. When a specific model is referenced, you will be referred to the manufacturer's instruction manual.

D.1 GENERAL INFORMATION

D.1.1 THEORY OF OPERATION

The Thermo Electron Corporation (TECO) and Advanced Pollution Instrumentation (API) carbon monoxide (CO) analyzers measure the amount of infrared (IR) light absorbed by CO in a sample of ambient air. The quantity of light absorbed is proportional to the concentration of CO in the air sample. A detailed discussion of the analyzer's measurement principle is contained in both of the manufacturers' instruction manuals. This document supplements both of the manufacturers' manuals with instructions for servicing and troubleshooting the analyzers.

D.1. 2 ANALYTICAL CYCLE

The analyzer determines the concentrations of CO in ambient air by passing polarized, single beam IR radiation through a rotating gas filter wheel to the sample cell and then the detector. The wheel contains two different entrapped gases: CO and nitrogen. The CO side for the Model 48 or CO/nitrogen mixture side for the Model 300 wheel acts to produce a reference beam that cannot be further affected by CO in the sample cell. The nitrogen side of the filter wheel is transparent to the IR radiation and therefore allows a measure beam that can be absorbed by CO in the cell. The detector converts the light to electrical energy, and the signal processing electronics manipulates the electrical information and displays the CO concentration. Figure D.1.1 illustrates the analyzer flow. For further details, refer to the manufacturer's instruction manual.

D.1.3 PRECAUTIONS

1. Prior to cleaning the analyzer, place the main power switch to the "OFF" position, and unplug the power cord. Avoid the use of chemical agents that might damage components.
2. Always use a three-prong, grounded plug on the analyzer.
3. Adhere to general safety precautions when using compressed gas cylinders (e.g., secure cylinders, vent exhaust flows).
4. Always use two people to lift and carry the analyzers.

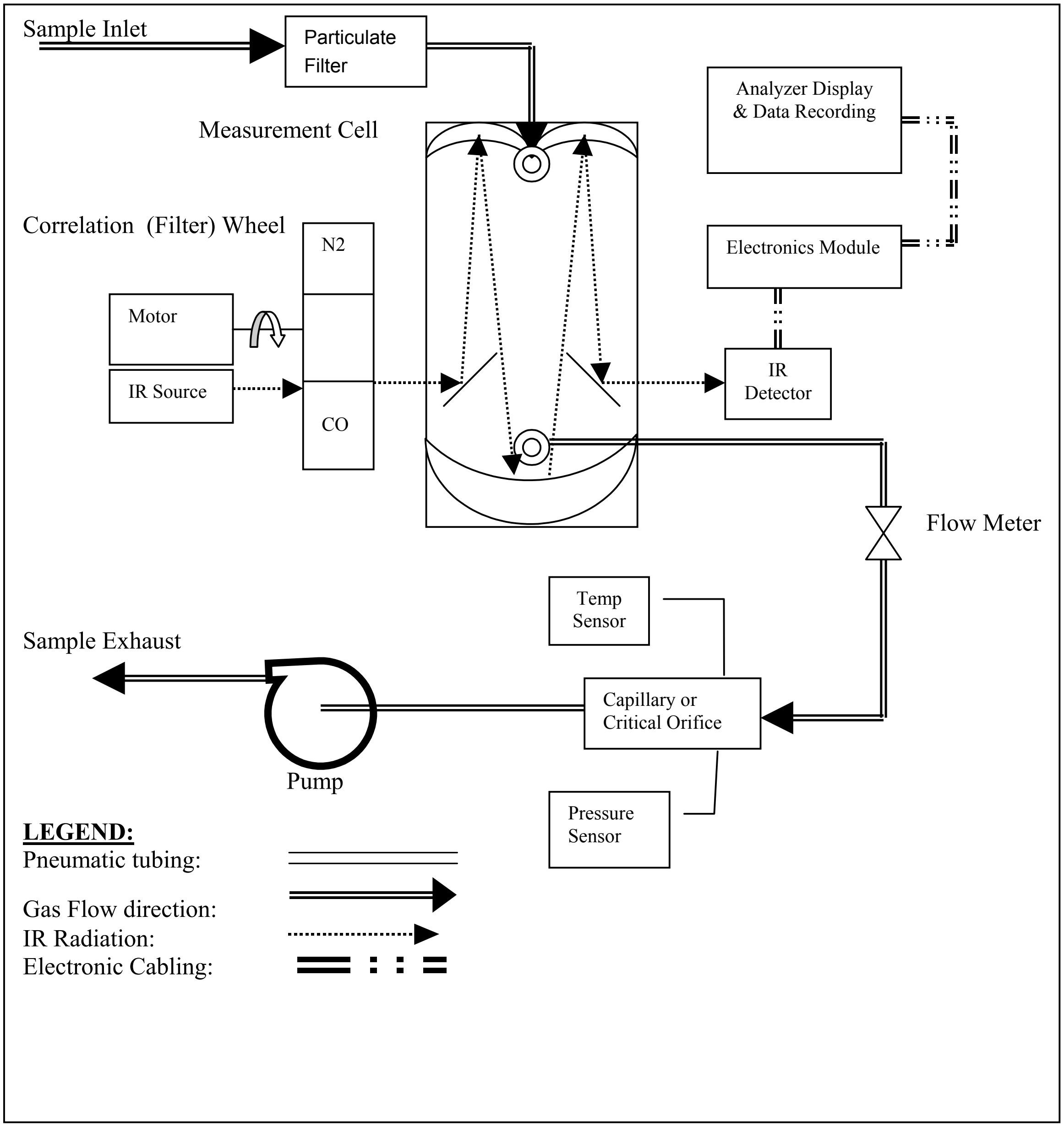


Figure D.1.1 Polarized IR, Gas Phase Correlation Carbon Monoxide Analyzer Flow and Sensor Schematic Diagram

D.2 INSTALLATION PROCEDURES

D.2.1 PHYSICAL INSPECTION

1) Unpack the analyzer and check it for shipping damage.

2) Remove the cover and check the plumbing for tightness. Make sure that all printed circuit boards are firmly seated and that other components have not become loose or damaged in shipment. Replace the cover.

D.2.2 INITIAL START-UP

1) Connect the sample line and span gas to the proper fittings on the back of the analyzer. Connect the port marked “VENT” to an appropriate outside vent.

NOTE: Do not pressurize, or restrict flow from this port.

2) Connect a recorder and the data acquisition system to the back of the analyzer.

3) Refer to the manufacturer’s instruction manual (Chapter 3 for Model 48C or Chapter 2 for Model 300) to become familiar with all controls and functions.

4) Plug the instrument into an outlet of the appropriate voltage and frequency.

5) Turn on the analyzer in accordance with the procedure outlined in the manufacturer’s instruction manual (Chapter 1.5 for Model 300 or Chapter 2 for Model 48C). The analyzer automatically enters the start-up mode. See the manufacturer’s instruction manual (Chapter 2 for Model 300 or Chapter 3 for Model 48C) for operation details.

D.3 ROUTINE SERVICE CHECKS

PRECAUTION: These routine service checks should be performed by qualified maintenance personnel only.
Power should be removed from the instrument before any servicing is performed.

D.3.1 GENERAL INFORMATION

The following routine service checks are performed in accordance with the maintenance schedule (Table D.1.3.1). Perform the checks at least at the prescribed intervals. Maintenance operations should be recorded weekly on the Quality Control Maintenance Check Sheet (Figure D.3.1). Each month the original shall be sent to the station operator’s supervisor. For a more detailed explanation of the following service checks and their safety precautions refer to the manufacturer’s manual.

23.4

D.3.2 DAILY CHECKS

Check the recorder chart and the digital display for any indication of analyzer malfunction or deviation. The front panel flow meter should indicate the flow representing approximately 1.0 standard liters per minute (slpm) as indicated on the most recent calibration report.

D.3.3 WEEKLY CHECKS

Perform the tasks described for the items listed below weekly. All initial and final readings should be recorded on the Quality Control Maintenance Check Sheet.

1) Zero Drift - Check the analyzer zero using the procedure given in the appropriate manufacturer's instruction manual. Adjust the zero if the deviation is greater than:

    a) 0.1 parts per million (ppm) (Model 48C) or

    b) 0.2 ppm (Model 300).

2) Span Drift - Check the analyzer span using the procedure given in the appropriate manufacturer's instruction manual. Adjust the span if the deviation is greater than:

    a) ±1.0% full scale (Model 48C) or

    b) ±1.0% of reading (Model 300).

3) Sample Flow - Check the sample flow. The front panel flow meter should indicate a flow representing approximately:

    a) 1.0 slpm (Model 48C) or

    b) 800 ccm ±10% (Model 300).

4) Inlet Particular Filter - Change the inlet particulate filter (see the maintenance section of the appropriate manufacturer's instruction manual).

D.3.4 MONTHLY CHECKS

Perform the tasks for the items listed below monthly:

1) Quality Control Maintenance Check Sheet - Send the Quality Control Maintenance Check Sheet to your supervisor.

2) IR detector light intensity - Check the IR detector intensity monthly.

    i) For the Model 48C, replace the IR source when the detector registers less than 100 kilo Hertz after cleaning optics, when the source stops functioning as an IR source, or after one year of continuous use, whichever comes first Refer to manual for procedures and part numbers.

    ii) For the Model 300, replace the IR source when the source stops functioning as an IR source or after one year of continuous use, whichever comes first. Refer to manual for procedures and part numbers.

D.3.5 ANNUAL CHECKS

Perform a multi-point calibration as outlined in Section D.7.

Table D.3.1

**MAINTENANCE SCHEDULE FOR THE
TECO MODEL 48C AND API MODEL 300 CARBON MONOXIDE ANALYZERS**

MAINTENANCE PERIOD	DAILY[a]		WEEKLY		MONTHLY		ANNUALLY	
ANALYZER MODEL:	48C	300	48C	300	48C	300	48C	300
Chart Trace	X	X						
Sample Flow			X	X				
Particulate Filter Element			X[b]	X[b]				
Zero			X	X				
Span			X	X				
Detector IR Intensity					X	X		
Clean Optics	During low detector IR intensity correction efforts and before annual calibrations.							
IR Source Replacement	After one year of continuous usage or as required							
Pump Diaphragms							X[c]	X[c]
Calibration							X	X
Sample Flow							X	X
Leak Check	After maintenance or annually							
Pneumatic Lines	Examine and clean as necessary							

[a] Or each day on which an operator is in attendance.
[b] Environmental conditions may require more frequent change.
[c] Replace every six months.

IDAHO DEPARTMENT OF ENVIRONMENTAL QUALITY
QUALITY CONTROL MAINTENANCE Check Sheet
TECO MODEL 48C & API MODEL 300 CARBON MONOXIDE ANALYZERS

LOCATION:_______________________________ MONTH/YEAR:______________________

STATION NUMBER:_________________ TECHNICIAN:______________________

ANALYZER PROPERTY No.:__________ AGENCY:__________________________

	Reading: Display/Data Logger **Zero**		**Span**		**Gas Cylinder Checks**		**Sample Flow Setting**	
Date	**As Found**	**Final**	**As Found**	**Final**	**Zero Setting**	**Span Setting**	**As Found**	**Final**
	/	/	/	/				
	/	/	/	/				
	/	/	/	/				
	/	/	/	/				
	/	/	/	/				
	/	/	/	/				

Operator Instructions:

1. Daily Checks: Air Flow (Record Weekly), Chart Trace (if applicable).
2. Weekly Checks: Zero and Span, Change/Replace Particulate Filter.
3. Monthly Intervals: Detector IR Intensity. Date Last Changed: __________________________
4. Annual Checks: Calibration. Date of Last Calibration: ______________________________
5. As Required: Clean Optics and replace IR source.

Date	**Comments or Maintenance Performed:**

Reviewed By:______________________________ Date:_______________

Figure D.3.1 Monthly Quality Control Maintenance Check Sheet

D.4 DETAILED MAINTENANCE PROCEDURES

D.4.1 CHANGING THE INLET SAMPLE FILTER

To change the inlet sample filter, use the procedures outlined in Section 11.2, page 93 of the Model 300 manufacturer's instruction manual or the supplemental documentation for the external filter housing for the Model 48C analyzer.

D.4.2 SERVICING THE SAMPLE PUMP

To service the sample pump, use the procedure outlined in Chapter 7, page 7-8 to 7-10 of the manufacturer's manual for Model 48C or the following sequence for the API Model 300.

1) Collect the following tools:
    - Flat blade screwdriver
    - 9/16 inch wrench
    - Phillips head screwdriver
2) Turn analyzer power off.
3) Remove the two tubes from the fittings on the top of the pump, leaving the fittings attached to the top of the pump.
4) Disconnect the power connections from the pump.
5) Remove the mounting screws holding the pump mounting bracket into the chassis. Remove the pump assembly from the chassis.
6) Remove the four flat blade screws from the top of the pump.
7) Remove the pump head from the body of the pump.
8) Holding the pump upside down to avoid losing the shims, grasp the edges of the diaphragm and turn the entire diaphragm counter-clockwise to unscrew it from the piston.
9) Remove the shims from the diaphragm screw, and install them onto the new diaphragm.
10) Holding the pump upside down, install the diaphragm onto the piston shaft by turning the entire diaphragm clockwise until the diaphragm is seated.
11) Separate the two pieces of the pump head and remove the rubber gasket containing the leaf valve gasket from the pump head. Install a new gasket from the rebuild kit.
12) Install the head and the pump is the reverse of the removal procedure.

D.4.3 CLEANING THE OPTICS

Use the procedure outlined in Chapter 5 page 5-1 of the manufacturer's manual for Model 48C or the following sequence for the API Model 300.

1) Clean the Model 300's IR detector glass.
    a) Use the following tools:
        i) #2 Phillips head screwdriver
        ii) Acetone or denatured alcohol
        iii) Distilled water
        iv) Cotton swab
        v) Lint free cloth (optional)
    b) Remove the power from the analyzer.
    c) Remove the cover from the analyzer.
    d) Locate and remove the preamp cover on the top of the bench at the rear of the chassis.
    e) Remove the two screws holding the preamp in place.
    f) Loosen the screws holding the detector to the bench, and slowly lift the preamp and detector out of the bench.
    g) Turn the preamp over so you can see the window on the detector. (Be careful, as the screws in the detector will probably fall out).
    h) Take a cotton swab or a lint free cloth and dip it into the alcohol. The swab/cloth should not be so moist that it drips. Use the moistened swab/cloth to scrub the window with the alcohol.
    i) Repeat Step h) using distilled water instead of alcohol.
    j) Using another swab/cloth, carefully dry the window being sure that there are no bits of cotton or cloth left behind.
    k) Reassemble the equipment, following the removal steps in reverse.
    l) Apply power to the analyzer. Wait one hour before continuing.
    m) Input zero air to the analyzer. Verify that the analyzer correctly measures the zero air.
    n) Adjust R7 on the Sync-Demod printed circuit assemply (PCA) until CO MEAS is between 50,000 and 70,000 counts, (3,000 – 4,400 millivolts [mV]).
    o) Allow the analyzer to stabilize at zero for 10 minutes. Press CALM-ZERO-ENTR (API use CAL-ZERO-ENTR).
    p) Input span gas. Allow 10 minutes for stability and press CALM-SPAN-ENTR (API use CAL-SPAN-ENTR).
    q) Perform the analyzer noise evaluation.
2) Clean the Model 300's mirrors.
    a) Use the following tools:
        i) #2 Phillips head screwdriver
        ii) 7/16 and 9/16 wrenches
        iii) Diagonal cutters
        iv) Oscilloscope
        v) Lint free cloth

vi) Acetone
vii) Service note “maximizing M300 energy”

b) Turn off the analyzer and unplug it from the power outlet.

c) Disconnect all electrical and pneumatic connections to the optical bench.

d) Remove the four screws that hold the optical bench to its shock mounts and remove the optical bench from the analyzer.

e) Remove the objective mirror (located at the end of the bench that is closest to the front of the analyzer) by removing the mounting screws, taking care to retain the three 0.010-inch shims (between the mirror and the bench).

f) Remove the field mirror (located at the end of the bench that is closest to the synchronous motor and IR source) using the same procedure as the objective mirror.

g) Remove the input mirror (the round knob at the top rear of the optical bench, adjacent to the IR source) by removing the two small screws that go through the mirror.

h) Remove the output mirror (the round knob at the top rear of the optical bench, adjacent to the IR detector) by removing the two small screws that go through the mirror.

i) Adhere to the following steps (j through m) for each mirror to be cleaned.

j) Blow off particulates using filtered air or dry nitrogen. Keep pressure to a minimum. If the pressure is too high, “sandblasting” action will occur and the mirror might become damaged beyond use.

k) Wet a lint free cloth with acetone and, using minimal pressure (the weight of the cloth), slowly drag the cloth across the optical surface. This action must be done slow enough so that the evaporation line of the acetone does not exceed 1/8 inch from the trailing edge of the cloth.

l) If contamination on the surface is of a water base, repeat Step k, replacing acetone with Windex® brand glass cleaner. If Windex® leaves behind a residue, repeat using the acetone.

m) Re-assemble the optical bench by replacing the mirrors in the reverse of the removal process. When tightening the screws on the objective and field mirrors ensure that the O-rings are in the grooves in the mirrors and that they are not pinched when tightening the mounting screws. Tighten the screws evenly and securely. WHEN INSTALLING THE FIELD AND OBJECTIVE MIRRORS IT IS VITAL THAT THE SHIMS BE PLACED BETWEEN THE MIRROR AND THE BENCH. THEY ARE NOT WASHERS THAT GO BETWEEN THE SCREW AND THE MIRROR.

n) Re-install the optical bench and reconnect all electrical and pneumatic lines.

o) Turn the analyzer on and allow it to warm up for 30 minutes.

p) If you have an oscilloscope follow the procedure “Maximizing M300 Energy,” located in the M300 operations manual. When you have completed the “Maximizing M300 Energy” procedure, continue with Step q. If you do not have access to the “Maximizing M300 Energy” procedure, then go to Step q.

q) Loosen (but do not remove) the screws for both the input and output mirrors. Display the CO MEAS test function on the instrument’s front panel. Fine adjust the position of the input and output mirrors by slightly rotating them until you achieve a maximum CO MEAS value.

r) Follow the calibration procedure, in Section D.7, for this analyzer.

D.4.4 SYSTEM LEAKS AND PUMP CHECK-OUT

Use the procedures outlined in Chapter 5, page 5-2 of the manufacturer's manual for Model 48C and Chapter 11.3, page 94 of the manufacturer's manual for Model 300.

D.4.5 REPLACING THE INFRARED LIGHT SOURCE

Use the procedures outlined in Chapter 7, page 7-4 of the manufacturer's manual for Model 48C. Follow the attached service document, 02-014A, for the Teledyne API Model 300.

D.5 TROUBLESHOOTING

The manufacturer's instruction manuals (Chapter 6 in the TECO Model 48C manual and Chapter 10 in the API Model 300 manual) contain information pertaining to troubleshooting and should be your first source of information. Additional problems that may occur are outlined below. Space is provided on the Monthly Quality Control Maintenance Check Sheet for recording malfunctions, causes, fixes, and actions taken to prevent recurrence.

The precautions listed in Section D.1.3 should be observed. Additionally, when moving or installing printed circuit boards or other components, turn the analyzer off and unplug the power cord. Properly grounded electrostatic discharge (ESD) grounding straps must be worn to prevent damage to sensitive electronic hardware.

D.6 ACCEPTANCE TEST PROCEDURES

D.6.1 GENERAL INFORMATION

The appropriate manufacturer’s instruction manual should be read thoroughly before beginning analyzer acceptance testing. In addition, a maintenance logbook and an Acceptance Test “Mini” Report (Figure D.6.1) should be initiated and pertinent information should be recorded.

D.6.2 PHYSICAL INSPECTIONS

Unpack the analyzer and check it for physical damage if this has not already been done. Verify that the analyzer is complete and includes all options and parts required by the purchase order. Remove the top cover from the analyzer, after properly donning an ESD grounding strap, and perform the following checks:

1) Make sure that all circuit boards are properly seated in their connectors by removing and reinserting each board.
2) Check for correct power cord phasing; standard wiring configuration has the black wire connected to the brass terminal of the plug, white to the copper terminal, and green to earth ground. Do not disassemble the power cord to inspect.
3) Start up the analyzer following the procedures in the manufacturer’s manual and verify that all switches and controls operate properly.
4) Leak check the analyzer using appropriate methods for the type of sampling system used.
5) Measure the output of each power supply and record the voltages in the comment section of the Acceptance Test “Mini” Report.

D.6.3 OPERATIONAL TESTS

Perform the following operational tests using a strip chart recorder connected to the analog output and record the results on the mini report. Segregate the recorder charts into 24-hour segments and write “Test Performed” across the bottom of the chart, followed by the following information::

- Date.
- Make, model number, and serial number of test analyzer.
- Range on which test is performed.
- Recorder trace color identification, if appropriate.
- Recorder identification.

Clear, precise notations should be entered on the chart indicating when the tests were started and ended recording pertinent information regarding sample flow, gas concentrations, voltages, interfering gases, etc.; and documenting any unusual conditions observed. Tests should be run in the range normally used in field operations. All tests should be run in parallel with a control analyzer and recorder whose charts are labeled as indicated above. Perform the test according to the following procedure.

1) Perform initial Start-Up activities on each analyzer - See Section D.2.2.

2) Zero and Span Stability - Using a calibrator and an appropriate gas standard (super blend), adjust the zero and span controls of the analyzer for proper response. Manually, or by using the calibrator timer program, run the zero and 80% span points. If performed manually, record mass flow controller readings on the recorder strip chart. After 24 and 72 hours, repeat the zero and span using the same calibrator settings. Using the stability test stamp, record the readings on the chart at the end of each test period. Record the changes in zero and span on the mini report. Compare the responses of the test analyzer to the purchase specifications.

3) Linearity - Using the calibrator, perform a linearity test at 80, 40, 20, 10, 8, 6, 4, 2% of full scale. The predicted response is calculated using the responses of the control analyzer as illustrated in the example provided in Table D.6.1 (typical response of the control analyzer are shown in column 2; typical responses of the CO analyzer under test are shown in column 3. For example, the predicted value at the 40 percent level = (41.6 / 83.1) x 82.5 = 41.3. The non-linearity at this level is 41.0 - 41.3 = -0.3%

Table D.6.1

Sample Linearity Test Data

Level (Percent)	Control Analyzer Net % Full Scale	Test Analyzer Net % Full Scale	Predicted (Calculated)	Non-Linearity % Full Scale (Calculated)
80	83.1	82.5	---	---
40	41.6	41.0	41.3	-0.3
20	20.5	20.6	20.4	+0.2
:	:	:	:	:
:	:	:	:	:
2	1.8	1.9	1.8	0.1

Record the test results on the chart and transfer the non-linearity numbers to the mini report. Compare the responses of the test analyzer to the purchase specifications.

4) Temperature/Voltage Stability – Perform the following Temperature/Voltage Stability tests to verify acceptability of the individual analyzer.

   a) Place the test analyzer in an environmental chamber, preheated to 40 °C. Connect the analyzer power cord to the variable voltage power supply. Connect the sample inlet to the sample manifold supplied from the mass flow controller (MFC) output. Power up the analyzer and allow it to run for at least one hour to stabilize.

The MFC should remain external to the chamber and should be powered by normal house power (115 voltage – alternating current [VAC]). Execute a temperature/voltage sequence using the following voltage set points while the analyzer is sampling zero air.

i. 105 VAC
ii. 110 VAC
iii. 115 VAC
iv. 120 VAC
v. 125 VAC
vi. 120 VAC
vii. 115 VAC
viii. 110 VAC

b) Record the tests results on the chart.

c) Repeat the temperature/voltage run while the analyzer is sampling a concentration equal to 80% full scale.

d) Compare the responses of the test analyzer to the purchase specifications.

e) Transfer the tests results to the mini report (Figure D.6.1).

5) Noise - The peak-to-peak noise during any of the tests should be less than two times the specification. Record the maximum peak-to-peak noise during the zero and span stability tests on the mini report.
6) Calibration - Perform a multi-point calibration on the analyzer using the calibration procedures outlined in Section D.7.

NOTE: The analyzer must be calibrated for the range on which it will be operated.

D.6.4 FINAL REVIEW

If acceptance tests are satisfactory pertinent information such as final sample flow, zero and span settings, etc. should be recorded in the logbook and on the Acceptance Test “Mini” Report (Figure D.6.1). The analyzer is ready for field use.

TECO MODEL 48C OR API MODEL 300 CARBON MONOXIDE ANALYZER
ACCEPTANCE TEST "MINI" REPORT

Date__________________________ Serial No.____________________________ Reviewed By_________________
By____________________________ ARB No._____________________________ Date of Acceptance____________

I. Physical Inspections — Pass / Fail / Final OK
- A. Checked for shipping damage.. ____ ____ ________
- B. Checked all electrical wiring.. ____ ____ ________
- C. Checked all plumbing for leaks...................................... ____ ____ ________
- D. Analyzer complete upon receipt..................................... ____ ____ ________

II. Operational Tests (all tests performed on 0-50ppm range)
- A. Acceptable Diagnostic Values. (See Analyzer Manual)
- B. Zero and Span Drift %FS Dev. Pass Fail Final OK

	%FS Dev.	Pass	Fail	Final OK
1. 24 Hour Zero Drift..	________	____	____	________
2. 24 Hour Span Drift @ ppm..........................	________	____	____	________
3. 72 Hour Zero Drift..	________	____	____	________
4. 72 Hour Span Drift @ ppm..........................	________	____	____	________
C. Line Voltage Test (105-125 VAC@ ppm)…….	________	____	____	________
D. Temperature Test				
1. Zero Shift: Step1 °C to °C...........	________	____	____	________
Step2 °C to °C...........	________	____	____	________
Step3 °C to °C...........	________	____	____	________
2. Span @ _____ppm Step1 °C to °C...........	________	____	____	________
Step2 °C to °C...........	________	____	____	________
Step3 °C to °C...........	________	____	____	________
E. Sample Flow Variation Test @ _____slpm........	________	____	____	________
F. CO Scrubber Efficiency Test..............................	________	____	____	________
G. Linearity				
1. 80% Full Scale @ ________ppm....................	________	____	____	________
2. 40% Full Scale @ ________ppm....................	________	____	____	________
3. 20% Full Scale @ ________ppm....................	________	____	____	________
4. 10% Full Scale @ ________ppm....................	________	____	____	________

- H. Final Analyzer Readings
  Sample Flow:__________sccm @ _ Flow Setting; Span Pot:_________ Range:_________

II. Linearity Test: Refer to QAPP, Appendix D, CO Analyzers, Section D.6.3, Step 3, for clarification and directions.

LINEARITY CHECK DATA SHEET				
LEVEL (Percent)	**Control Analyzer Net % Full Scale**	**Test Analyzer Net % Full Scale**	**Predicted (Calculated)**	**Non-Linearity % Full Scale (Calculated)**
80			----------	----------
40				
20				
10				
8				
6				
4				
2				

IV. Comments/Maintenance Performed

Figure D.6.1 Acceptance Test "Mini" Report

D.7 CALIBRATION PROCEDURES

D.7.1 INTRODUCTION

The Department of Environmental Quality calibrates CO analyzers using a precise quantitative dilution, with standard reference method zero air, of a compressed cylinder of known CO gas concentration. Zero air is mixed with the CO using a calibrated dilution apparatus to provide five concentrations from 0% to 90% of the analyzer's operating range. The CO standard is initially certified against a National Institute of Standards and Technology (NIST) Standard Reference Method and thereafter recertified annually. The dilution apparatus (mass flow controller, etc.) are also certified and recertified every three months against laboratory flow standards.

D.7.2 APPARATUS

Figure D.7.1 is a diagram of a typical CO dynamic calibration system. Connections between components in the calibration system downstream from the CO cylinder should be of borosilicate glass, FEP Teflon®, or other non-reactive materials. The apparatus should meet the following specifications:

1) Equipment
    a) Dilution apparatus, including two calibrated MFCs
    b) Two digital panel meters
    c) Manual or solenoid valves for positive gas shut-off, such as a TECO Model 146C Multi-gas Calibrator System or an API Series 700 Mass Flow Multi-Gas Calibrator.
2) CO Standard - Certified and traceable to a NIST CO reference material.
3) Zero Air - Air containing <0.1 ppm CO provided by a calibration unit, zero air cylinder, or other zero air source.
4) Airflow Connections - Use ¼-inch or 1/8-inch FEP Teflon® tubing for airflow connections. All fittings in contact with CO must be made of 3/16 stainless steel or FEP Teflon®.
5) CO Calibration Datasheet – Record all pertinent information on the CO Calibration Datasheet (Figure D.7.2).

D.7.3 "AS-IS" CALIBRATION

Other than routine daily checks, analyzer repairs or adjustments should not be made prior to the "as-is" calibration. Perform the calibration following these steps:

1) Record analyzer parameters and site conditions on the Calibration Datasheet (Figure D.7.2). Refer to the manufacturer's instruction manual (Chapter 4, for the TECO 48C or Chapter 8 for the API 300) for detailed information regarding calibration procedures.
2) Remove contaminants from the CO pressure regulator:
    a) Purge the regulator and delivery system with CO to a safe vent after opening the cylinder valve.
    b) If possible, leave the regulator attached to the cylinder between calibrations (only if there is no transport involved). If the cylinder must be transported, remove the regulator and secure the cylinder with the cap.

3) Find the CO operating range.

4) Using FEP Teflon® tubing, connect the CO and zero air to the appropriate inlet fittings on the dilution system.

5) Disconnect the analyzer's sample probe at the station's sampling manifold and connect it to the outlet manifold of the dilution system apparatus. Cap the open port on the station's sampling manifold.

6) If using a zero air cylinder, attach and flush the zero air regulator, being careful not to introduce contamination.

7) Once the dilution airflow rate is chosen, determine the required flow of CO gas to obtain approximately 90% of full scale. Use the following equation and those equations provided with the mass flow meter transfer standards. Record the mass flow meter equations on the Calibration Datasheet. Do not adjust either MFC to less than 10% of full scale.

$$F_{CO} = \frac{C_0 * F_a}{C_{CO} - C_0}$$

Where: F_{co} = CO flow, sccm (standard cubic centimeters per minute)
F_a = Air flow, sccm
C_{co} = CO cylinder concentration, ppm
C_o = desired concentration (diluted CO concentration, ppm)

8) Open the air regulator outlet valve on the dilution apparatus; set the flow so that when the CO gas flow rate is at its maximum, the diluted CO concentration is calculated to be approximately 90% of full scale. The total flow must exceed the total demand of the analyzer(s) connected to the calibrator's output manifold to insure that no ambient air is pulled into the manifold vent (see caution note below).

9) Allow the analyzer to sample zero air until a stable zero response is obtained. Adjust the analyzer's zero control to obtain the required zero set point on the chart recorder and again allow the analyzer to stabilize. Obtain approximately 10 minutes of stable recorder trace and record the response on the Calibration Datasheet.

CAUTION: Vent or scrub the excess CO from the outlet manifold to the outside using a large diameter vent line.

10) Adjust the CO gas flow (F) to the value calculated in Step 8 with the MFC CO potentiometer set to obtain approximately 90% of full scale. It may require an hour or more for the reading to stabilize as the MFC, dilution apparatus, and analyzer must be conditioned to the calibration gas.

10) After the recorder chart response has stabilized, record the MFC displays and the corresponding chart response on the Calibration Datasheet.

11) Calculate actual standard cubic centimeters per minute for the CO gas and dilution air flow and record on the Calibration Datasheet.

12) Reset the CO MFC potentiometer to obtain responses of approximately 50%, 20%, and 10% of full scale. After the analyzer has stabilized for each point, record the MFC displays, calculate the actual standard cubic centimeters per minute flow, and record on the Calibration Datasheet along with the corresponding recorder chart response.

13) Repeat the zero reference point (Step 9). Allow the zero trace to stabilize on the recorder chart. The zero response should reproduce the original zero within 1% of full scale. If it does not, determine the cause and correct the problem before continuing.

13) Perform the following calculations:

NOTE: The calculations assume that the CO analyzer is linear (i.e., the calibration curve of the net chart recorder response versus concentration is a straight line within 1% of full scale at each point). If it is not, troubleshoot the analyzer and calibration system and correct the problem before continuing.

a) Calculate the CO and dilution airflow rates in standard cubic centimeters per minute, using the certification equations provided.

b) Using the flow rates (sccm), calculated for Steps 7 and 12, calculate the true CO concentration for each calibration point. Record under "[CO]" on the Calibration Datasheet.

True CO output concentration, ppm:

$$[CO]_{out} = \frac{C_{CO} * F_{CO}}{F_{CO} + F_a}$$

c) Determine the “NetDAS” response (ppm) by subtracting the average data acquisition system (DAS) zero response from the chart recorder’s response.

d) Calculate the deviation from true CO concentrations:

$$\%Dev. = \left(\frac{NetDAS[CO]}{[CO]_{out}} - 1\right) * 100\%$$

Where: NetDAS[CO] = Net Data Acquisition System reported CO concentration.

NOTE: Obtain the data necessary to complete the calculations from the Calibration Datasheet.

e) Calculate the least square linear regression coefficients (slope and intercept) using all calibration points, including zero points, and record on the Calibration Datasheet.

$$y = mx + b$$

$$m = \frac{y - b}{x}$$

Where: $x = [CO]_{out}$: true CO concentration, ppm
y = NetDAS[CO], ppm
m = slope, unitless
$b = y_{intercept}$, ppm

f) Calculate the “as-is” change from the previous calibration:

$$m = \left(\frac{(As\_Is\_Slope) - (Old\_Slope)}{Old\_Slope}\right) * 100\%$$

g) Plot the CO calibration curve, NetDAS, or net chart versus $[CO]_{out}$.

h) If the slope, m, is between 0.95 and 1.05, and b agrees with the zero reading within 1% of full scale, then the analyzer is in calibration, and no further adjustments are needed.

D.7.4 FINAL CALIBRATION

If the slope, m, calculated in Step 15f (Section D.7.3, above) is less than 0.95 or greater than 1.05, an adjustment and final calibration are necessary. Adjust the CO analyzer to correct the deviation as follows:

1) Repeat the 90% of full scale span concentration (Section D.7.3, Step 10).
2) Adjust the front panel span thumb wheel switch until the analyzer reads the true CO concentration.

NOTE: Increasing the thumb-wheel switch number increases the analyzers response.

3) Repeat the zero reference point (Section D.7.3, Step 9).
4) Repeat Steps 1 through 3 in this section until no further adjustments are needed.
5) Repeat calibration points (90%, 50%, 20% and 10% of full scale) for the final calibration. Complete the Calibration Datasheet and a calibration curve.

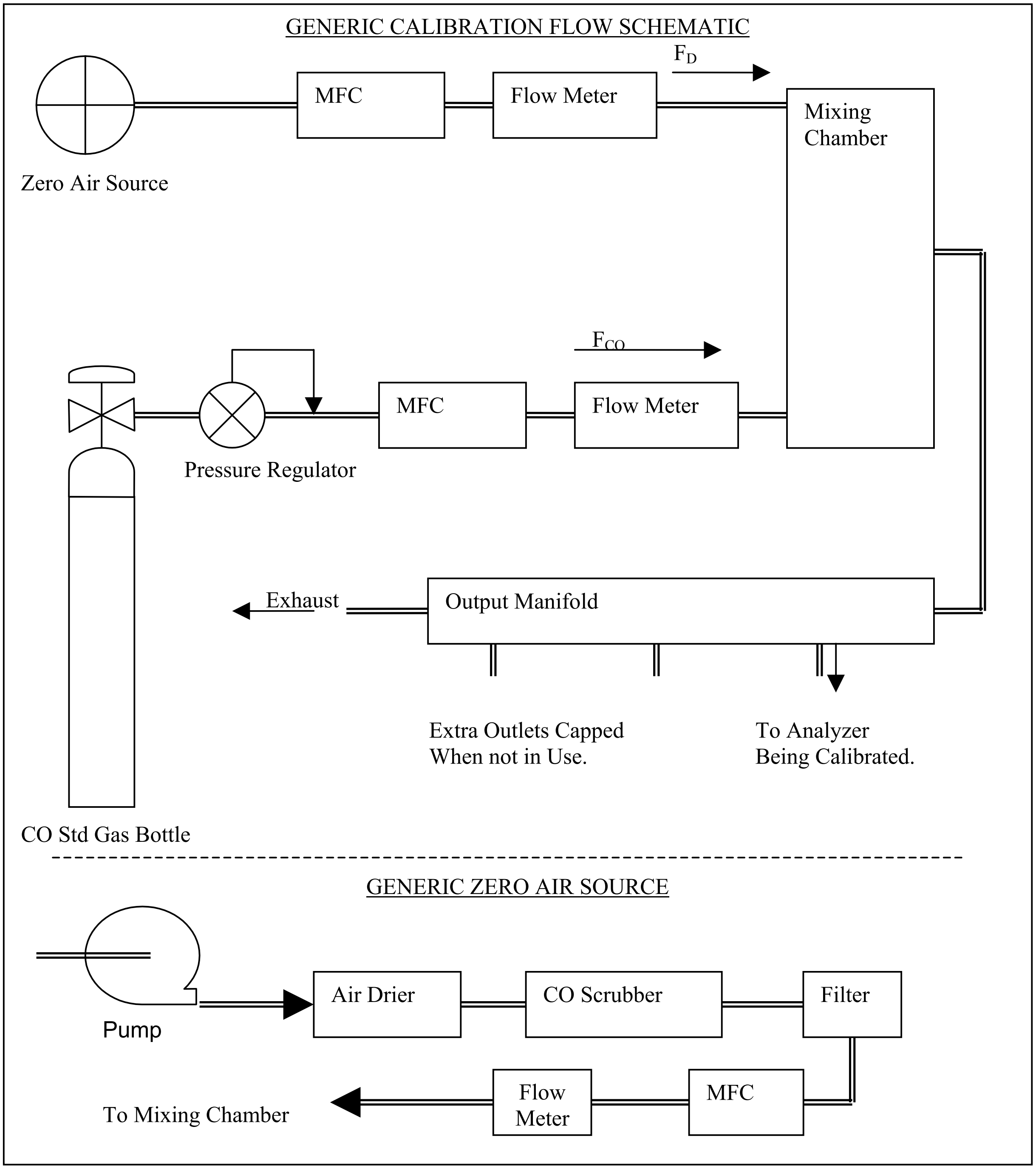


Figure D.7.1 Typical Carbon Monoxide Dynamic Calibration System Diagram

DYNAMIC CO CALIBRATION DATASHEET

Site Name________________________________ Calibration: As Is ________________________Final____________
Site No.__________________________________ Date____________________ Log No.______________________
Site Temperature___________________________ Barometric Pressure_______________ Site Elevation____________
INSTRUMENT: Make and Model____ Property No.____________
Serial No.________________________ Span__________________________ Zero___________________
Range__________________ Airflow_______________________ slpm. at _________________ setpoint
Primary Data Acquisition System (DAS): Make and Model____
Property No.____________________________________ Serial No.______________________________
Transfer Standard: Make and Model_______________________________________ Property No.____________
Serial No.________________________ Date Certified__________________ Cert Expires____________
0-100 sccm MFC: Airflow =________________________ Display ± __________________ sscm (C0 gas)
0-10 sccm MFC: Airflow =_________________________ Display ± __________________ sscm (C0 gas)
Compressed Gas Cylinder: Cylinder No._______________________ Cylinder Pres.________________________ psi
Assay__________________ ppm Date Certified_______________________ Cert Expires____________
Outlet Pressure____________________________________ psi
Dilution Air: Source____ Property No.____________
Outlet Pressure____________________________________ psi

Transfer Standard					$[CO]_{out}$ (ppm)	Instrument		
CO Gas Flow		Dilution Unit		Total Flow		Chart (% FS)	DAS (ppm)	Net DAS
Display	sccm	Display	sscm	Sscm				

= =

Percent deviation from True: $$\left(\frac{NetDAS[CO]}{[CO]_{out}} - 1\right) * 100\% = \_\_\_\_\_\_\_\_\_\_\_\_ \%$$

Linear regression: Analyzer response, ppm = (__________) x $[CO]_{out}$ ± (__________)
Slope Intercept

As is change from previous calibration, dated ________________

$$\frac{\text{As Is Slope - Old Slope}}{\text{Old Slope}} \times 100\% = (\_\_\_\_\_\_\_\_) \times 100\% = (\_\_\_\_\_\_\_\_\_\_) \%$$

Comments:

Calibrated by:___________________________________ Checked by:___________________________________

Figure D.7.2 Carbon Monoxide Calibration Datasheet

TELEDYNE
INSTRUMENTS
Advanced Pollution Instrumentation
A Teledyne Technologies Company

6565 Nancy Ridge Dr., San Diego, CA 92121-2251
Phone (858) 657-9800 Fax: (858) 657-9818 Toll Free 1800 324-5190
E-mail: api-customerservice@teledyne.com http://www.teledyne-api.com

3.1.1 Service

02-014A, 15 March, 2002

INSTRUCTIONS FOR REPLACING THE DETECTOR/PREAMP IN A TAPI M3XX ANALYZER

I. PURPOSE:
The purpose of this service note is to provide instructions on how to replace detectors in an M3XX analyzer.

II. PARTS:
009530000

III. SCOPE:
This applies to API model M300/M300H/M360 and the M320.

IV. TOOLS:
Phillips screwdriver

V. PROCEDURE:

1. On the analyzer, press SETUP-MORE-VARS and change the password to 929. Press ENTR.
2. Press NEXT until you see RS232_MODE record this number. Press NEXT until you see FACTORY_OPTIONS. Write down the number that this variable is set to.
3. Remove power to the analyzer.
4. Remove the top cover from the analyzer.
5. Locate the detector/preamp cover. This is mounted in the left rear corner of the analyzer (on top of the bench). Remove the two #6 screws and remove lift off the cover. (Location of screws shown in figure 1)
6. Follow the cable from the detector to the main board and disconnect it at the main board.
7. Follow the cable from the detector to the Power Supply Module and disconnect at the Power Supply Module.
8. The detector/preamp board is secured onto standoffs by two screws. There are also two holes in the PCA (near the detector), which allow you to insert a screwdriver down through the PCA to access the two screws, which secure the detector to the bench. (Locations of screws shown in figure 2.)
9. Remove the two screws holding the detector to the bench. Remove the two screws holding the detector PCA to the standoffs. (Location shown in figure 2.)
10. Remove the entire detector assembly from the bench ensure that the o-ring for the detector is removed as well. Protect the detector from ambient light by wrapping the detector in a piece of aluminum foil.
11. Replace the o-ring that was removed with the detector and replace with the orange o-ring that comes with the new board.
12. **NOTE:** The lock washers securing the detector to the bench must be replaced with two #4 flat washers. Install the new detector inserting the small screws with flat washers through the detector flange, and then carefully positioning the detector into the hole in the bench. Hand tighten the screws. Install the two

screws with lock washers for the preamp board, and then snug down the detector screws. **CAUTION! DO NOT TIGHTEN THE TWO DETECTOR SCREWS TO MORE THAN 30 IN-LBS.**

13. Perform a leak test on the bench assembly.
    a. Bypass the sample pump by connecting the input and output lines.
    b. Connect the leak checker to the exhaust port on the rear panel.
    c. Cap the sample port.
    d. Pressurize the system to 15 PSI and ensure the system maintains the pressure for 5 minutes. If not check detector assembly for leaks and repeat.
    e. **IMPORTANT –** upon the conclusion of test release pressure slowly.
    f. Install the detector/preamp cover. Connect the cable from the preamp to the main board, and the cable from the preamp to the Power Supply Module.
14. Power up the analyzer.
15. Allow the analyzer to warm up for at least two hours.
16. Input zero air and allow the analyzer to stabilize for 15 minutes.
17. Adjust R7 on the Sync-Demod board until the COMEAS value is between 4000 and 4500 counts.
18. Press SETUP-MORE-DIAG-ENTR. Press NEXT until you see DARK CAL. Press ENTR-CAL-ENTR. After two minutes it should finish it's dark calibration and you can exit to the main menu.
19. Allow 15 minutes on zero air for analyzer to stabilize. Press CAL-ZERO-ENTR to ZERO the analyzer. Exit to the main menu.
20. Input a span gas value and allow the analyzer to stabilize for 15 minutes.
21. Press CAL-CONC and enter the value of span gas. Press ENTR. Exit to main menu.
22. Press CAL-SPAN-ENTR to SPAN the analyzer. Exit to main menu.
23. If the analyzer does not give you a SPAN or ZERO button when performing steps 17-20 then you must RESET the MEMORY (follow steps 22-27). If it does give you a SPAN or ZERO button then go to step 30.
24. Press SETUP-MORE-DIAG and change the password to 929. Press ENTR.
25. Press NEXT until you see MEMORY RESET or similar. Press ENTR. Press EEPROM-ENTR. The analyzer will now go through a power up cycle.
26. When it has powered up, press SETUP-MORE-VARS and change the password to 929. Press ENTR. Press NEXT until you see FACTORY_OPTIONS. Press ENTR.
27. Take the number that you recorded in step 2 enter it Press ENTR.
28. Press PREV until you see RS232_MODE. Enter the value recorded in step 2. Press ENTR. Exit to the main menu.
29. When it comes up, perform the DAC calibration found in Section 9.2 of the M300 manual.
30. Cycle power on the analyzer.
31. Once the analyzer has powered up repeat steps 13-21
32. This completes calibration of the analyzer

Figure 1.

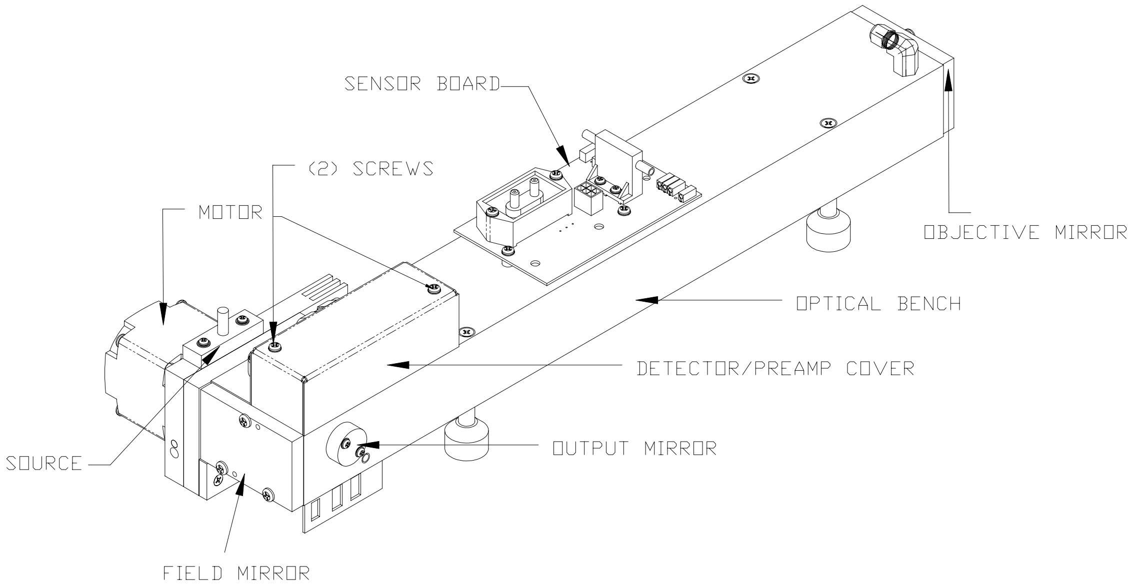


Figure 2.

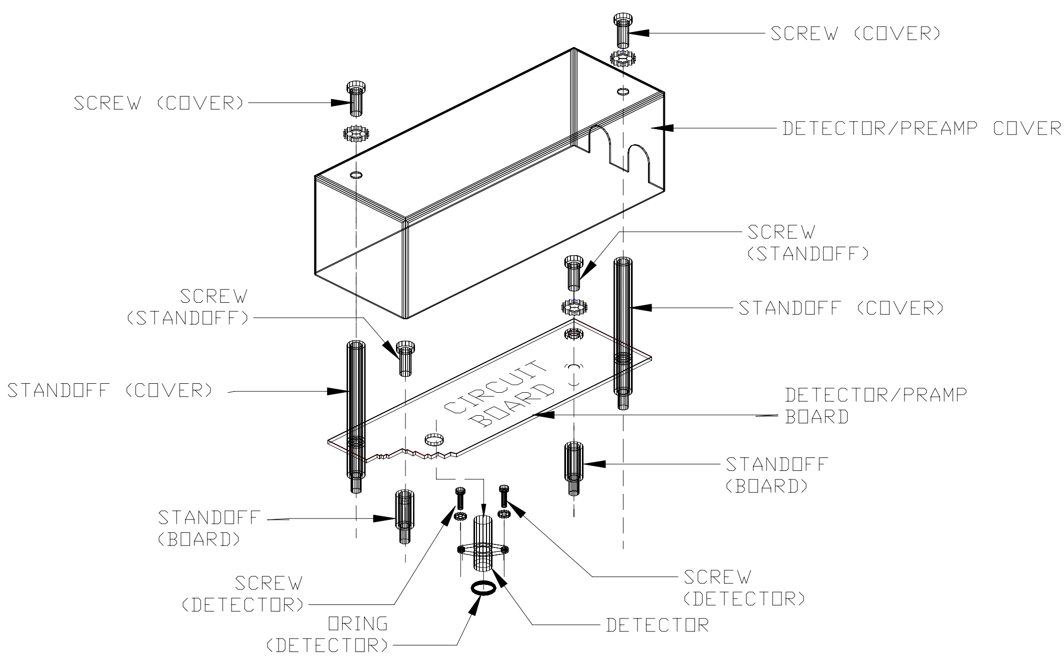
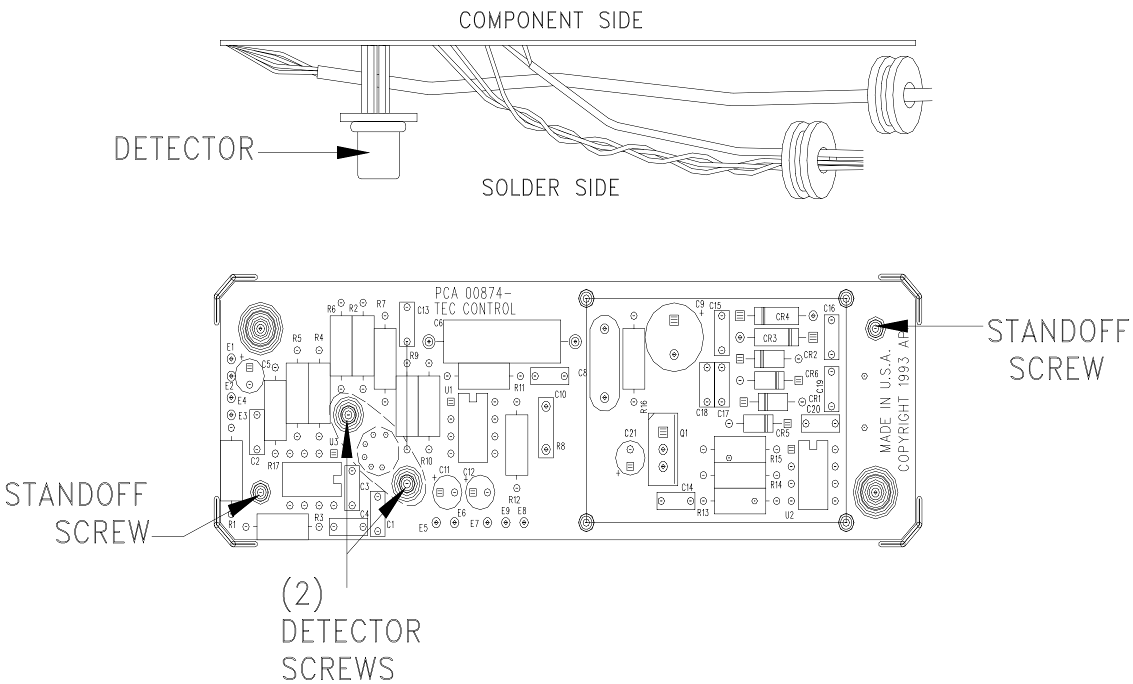


Figure 3

Detector/Preamp Board Assembly



APPENDIX E: NITROGEN OXIDE ANALYZER

STATE OF IDAHO

DEPARTMENT OF ENVIRONMENTAL QUALITY

AIR MONITORING QUALITY ASSURANCE

STANDARD OPERATING PROCEDURES

FOR

AIR QUALITY MONITORING

TECO 42 OXIDES OF NITROGEN ANALYZER

JULY 2002

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TECO 42 OXIDES OF NITROGEN ANALYZER

FIGURES

TABLES

TECO 42 OXIDES OF NITROGEN ANALYZER

TABLE OF ACRONYMS, UNITS, AND CHEMICAL NOMENCLATURE

CE	converter efficiency
ccm	cubic centimeter per minute
CFR	Code of Federal Regulations
LED	light emitting diodes
lpm	liters per minute
MFM	mass flow meter
NIST	National Institute of Standards and Technology
NO	nitrogen oxide
NO_2	nitrogen dioxide
NO_X	nitrogen oxides
ppb	parts per billion
ppm	parts per million
TECO	Thermo Electron Corporation
URL	upper range limit

E.1 GENERAL INFORMATION

Before beginning acceptance testing of the Thermal Environmental Corporation (TECO) 42 oxides of nitrogen analyzer, read the instrument's operating manual thoroughly. Then, initiate an Acceptance Test Log (Figure E.1.3) and an Acceptance Test Mini Report (Figure E.1.4). Record the dates of the individual tests, problems, contacts with the manufacturer, and any other pertinent information on the Acceptance Test Log.

E.1.1 Physical Inspection

Unpack the analyzer and check for physical damage. Verify that the analyzer is complete and includes all options and parts required by the specifications and purchase order. Remove the top cover from the analyzer and perform the following checks:

1. Make sure all circuit boards are properly seated in their connectors by removing and reinserting each board.

2. Check for correct power cord phasing. Standard wiring configuration has the black wire connected to the brass terminal of the plug, white to the copper terminal, and green to earth ground.

3. Assemble the analyzer following the procedures outlined in Chapter II of the manufacturer's manual.

4. Start the analyzer following the procedures outlined in Chapter III of the manufacturer's operating manual, and verify that all switches and controls operate properly.

5. Leak check the analyzer using appropriate methods for the type of sampling system used.

6. Measure the output of each power supply and record the voltages on the Acceptance Test Mini Report.

NOTE: The installation should always be followed by calibration.

E.1.2 Operational Checks

Perform the following operational checks using a strip chart recorder connected to the analog output and record the results on the Acceptance Test Mini Report. Cut the recorder charts in 24-hour segments and label the bottom of each chart with the following:

Test performed
Date Test performed
Make, model number, and serial number of test analyzer
Range on which test was performed
Recorder trace color identification (if appropriate)

NOTE: Record on the strip chart the trace values indicating the analyzer response to the test gas.

Clear, precise notations should be entered on the chart indicating when the tests were started and ended; pertinent information regarding sample flow, gas concentrations, voltages, interfering gases, etc.; and any unusual conditions observed. Tests should be run in the range normally used in field operations. All tests should be run in parallel with a control analyzer and recorder whose charts are labeled as indicated above.

Following are a list of Acceptance Tests to be performed on newly obtained equipment.

- Diagnostic and Voltage Test – Record all pertinent diagnostics and measured values on the Diagnostic Record form (Figure E.1.5). An example is provided in Figure E.1.1.

Diagnostics	Information	Indicated Value
1	Cooler temp. ˚ C	-3
2	No span factor	0.98

Figure E.1.1. Sample information for Diagnostic Record form

- Zero/Span Stability - Using a gas calibrator and an appropriate gas standard (super blend), adjust the zero/span controls of the analyzer for the proper response. Manually or by using the calibrator timer program, run zero/span points at 80% of full scale for the analyzer. Repeat the zero/span using the same calibrator settings for 30 days. Record the readings of the zero/span drift on the Linearity Zero/Span Drift Tests form (Figure E.1.6). Record the changes in zero/span on the Acceptance Test Mini Report (Figure E.1.4).

- Linearity - Using the automatic gas calibrator remote program, perform a linearity test at 80, 40, 20, 10, 8, 6, 4, and 2% of full scale. The predicted response is calculated using the responses of the reference analyzer as illustrated in Figure E.1.2.

Level	Reference Net % Full Scale Chart	Test Net % Full Scale Chart	Predicted (Calculated)	Non-Linearity % Full Scale (Calculated)
80	83.1	82.5	---	---
40	41.6	41.0	41.3	-0.3
20	20.5	20.6	20.4	+0.2
:	:	:	:	:
:	:	:	:	:
2	1.8	1.9	1.9	0.1

Figure E.1.2. Sample linearity test information

For example, the predicted value at the 40% level is: $\frac{41.6 \times 82.5}{83.1} = 41.3$.

The non-linearity at this level is 41.0 - 41.3 = -0.3 %

Record the test results on the Linearity Zero/Span Drift Tests form (Figure E.1.6) and transfer the non-linearity numbers to the Acceptance Test Mini Report (Figure E.1.4). Compare the results to the purchase specifications.

- Temperature and Voltage Stability - Place the test analyzer in an environmental chamber and connect the analyzer power cord to the variable voltage power strip. Connect the sample inlet to the sample manifold supplied by an automatic calibration system. The reference analyzer should remain external to the chamber. The reference analyzer should operate on normal house power. Initiate a temperature/voltage run while the test and reference analyzers are sampling zero air. Repeat the temperature/voltage run while the analyzers are sampling a concentration equal to 80% of full scale. Titrate 50% of the nitrogen oxide (NO) during the 80% of full scale test. Record the test results on the Temperature/Voltage Test form (Figure E.1.7). Compare the responses of the test analyzer to the purchase specifications. Transfer the test results to the Acceptance Test Mini Report (Figure E.1.4).

- Converter Efficiency - Prior to the test, set the converter efficiency to 100% on the TECO 42. Determine the converter efficiency. The titration step at 500 parts per billion (ppb) of nitrogen dioxide (NO_2) must be two hours in duration. Use the 0-1000 ppb range and the timer program of the gas calibrator to provide the test concentrations at 0.5 ppm NO_2. Following the test, set the converter efficiency to the value determined.

NOTE: The converter efficiency must be at least 98% at the minimum temperature. For the TECO 42, the minimum temperature is 325 $\pm$ 5 ˚C.

- Confirm that all recorder charts are properly labeled, the mini report is complete, and the analyzer meets or exceeds all specifications. Give the test package (mini report, recorder charts, and log) to your supervisor for review. After the test results have been reviewed and accepted, contact the Administrative Services Division property clerk to have a property number assigned and attached to the analyzer, notify the property clerk that the analyzer completed acceptance testing, complete a move tag, and place the analyzer in the stockroom.

IDAHO DEPARTMENT OF ENVIRONMENTAL QUALITY
ACCEPTANCE TEST LOG

Make TECO Model 42

Date	Action

Figure E.1.3. Acceptance Test Log

ACCEPTANCE TEST "MINI" REPORT

Make_________________________ Model_______________________ Date_________________________
Serial_________________________ ID #_________________________ Reviewed By__________________

		Pass	Fail	Comments
I.	PHYSICAL INSPECTION			
	A. Shipping damage	____	____	____________________
	B. Electrical wiring	____	____	____________________
	C. Plumbing leaks	____	____	____________________
	D. Completeness	____	____	____________________
II.	Operational Test			
	A. Control/Indicators	____	____	____________________
	B. Diagnostics	____	____	____________________
	C. Span/zero	____	____	____________________
	D. Programming	____	____	____________________
III.	Test Performed			
	A. Zero drift	____	____	____________________
	B. Span drift	____	____	____________________
	C. Linearity	____	____	____________________
	D. Temperature (zero/span)	____	____	____________________
	E. Voltage (zero/span)	____	____	____________________
IV.	Converter Efficiency	____	____	____________________
IV.	Maintenance Performed	____	____	____________________

Average Diff. True-Ind. Must be less than 1% of Full Scale (.01V)

Linear Regression Slope____________ Intercept____________ Correlation____________________
*Attach charts and forms

Figure E.1.4. Acceptance Test "Mini" Report

IDAHO DEPARTMENT OF ENVIRONMENTAL QUALITY
DIAGNOSTIC RECORD

Make________________________ Model________________________
SN__________________________ Test Date______________

Diagnostics	Information	Indicated Value	
cl	cooler temp		
ct	converter temp		
rc	rx chamber temp		
bl	NO zero background		
b3	NOx zero background		
S.F.	NO span factor		
b.f.	NOx balance factor		
ce	converter efficiency		
nr	thumb-wheel reading		
0	analog offset		
dip	dip switch status		
	press/temp		
	temp on/off		
	temp		

Flow:
Ozone________________
Sample________________

Vacuum________ Averaging____________________

Figure E.1.5. Diagnostic Record

IDAHO DEPARTMENT OF ENVIRONMENTAL QUALITY

Make__________________ Model_________________
SN____________________ Test Date_______________

LINEARITY TEST

Reference			Test			
Level	Gross % FS	Net % FS	Gross % FS	Net % FS	Predicted (Calculated)	Non-linearity
0						
80						
40						
20						
10						
5						
2						

ZERO/SPAN DRIFT

	Zero		Span	
	% FS	% FS Dev	% FS	% FS Dev
Initial				
30 Day				

Figure E.1.6. Linearity, Zero/Span Drift Tests

IDAHO DEPARTMENT OF ENVIRONMENTAL QUALITY
TEMPERATURE/VOLTAGE TEST

Make_________________ Model________________
SN___________________ Test Date______________

Temp (˚ C)	Voltage (V)	Reference	Test	% FS

Figure E.1.7. Temperature/Voltage Test

E.2 CALIBRATION PROCEDURE

E.2.1 Introduction

This calibration procedure employs a set of National Institute of Standards and Technology (NIST)-traceable, certified mass flow controllers that dilute a NIST traceable, certified NO gas mixture with zero grade air. The gas dilution system, with these gases, is operated to produce a multi-point “as is,” and, if necessary, a multi-point ”final” calibration. This document describes the procedure using portable, certified mass flow meters, a blended gas cylinder, and a certified ozone photometer.

The nitrogen oxide (NO_x) analyzer is calibrated when known concentrations of NO and NO_x are entered into the analyzer until readings stabilize. The calculated gas quantity from the calibration system is entered on the NO_x analyzer’s input thumbhole. The “STAT” button is pushed until the display shows the level of the gas being calibrated. When the “CAL” button is pushed followed by “ENTER,” the appropriate NO or NO_x channel is calibrated. The “ENTER” button must also be pushed while the display reads “STORE” to save the calibration value in the event that there is a power failure.

E.2.2 Apparatus

The equipment needed to calibrate the NO_x analyzer are listed below:

1. NIST traceable nitric oxide gas mixture (at 50 parts per million [ppm])
2. Gas calibration system
3. Set of certified 4-in-1 mass flow meters (MFMs)
4. Calculator capable of linear regression
5. Calibration forms (MLD 47A) or computer forms (spreadsheets)
6. Tool kit
7. Data logger and a chart recorder
8. Clean air package or air purifier
9. Stainless steel gas regulator for the Calibration Gas Audit (CGA)
10. Timer/stopwatch

All connections between components in the calibration system should be made of glass, Teflon®, or other non-reactive materials.

E.2.3 Instrument Calibration

Follow the steps listed below to calibrate the NO_x analyzer

1. Initial Setup - This procedure follows the calibration guidelines in Section 3 (page III-2) and Section 4 (pages IV-1 to IV-14) of the TECO 42 instrument manual.
    a. Plug in the MFM flow transfer standards. They should warm up for at least one hour.
    b. Plug in the calibrator and turn on the power switch. Let the instrument warm up for at least one hour. Place the stainless CGA regulator on the NO cylinder.

c. Purge the calibration gas through the regulator three times before use. This will reduce NO_2 contamination. Connect the gas calibration system to the TECO 42 and the gas standard. Place the output tubing of the gas calibration system onto the inlet of the NO in-line particulate filter. Place a cap on the NO glass manifold inlet.

2. Calibration System Connection

   a. Connect zero air to the calibration system and adjust the air pressure to the manufacturer's specifications.

   b. Purge the gas calibration system with zero air at a flow rate of 5 liters per minute (lpm) while the gas calibration system warms up.

3. Data Recording Preparation

   a. Disable the data logger for the NO_x, NO, and NO_2 channels.

   b. Prepare all the headings and other information on the hardcopy calibration forms (Figure E.2.1-3) or on the laptop computer spreadsheet form (Figure E.2.0.2 spreadsheets, Quattro® or Excel®).

4. Analyzer Flow Checks- Other than routine daily checks, analyzer repairs or adjustments should not be made prior to the "as-is" calibration.

   a. With the 4-in-1 flow transfer standard, check the TECO 42 flows. Disconnect the ¼ inch Swagelok connection for the ozone flow. (If the dry airflow is not available from the rear of the instrument, the flow should be plumbed to make this possible.) This port is labeled "Dry Air" in the back of the instrument.

   b. Connect this port to the 1-liter or 3-liter flow standard. Record the flow standard's display. Determine the flow by using the certification equation for this flow standard. The units in the equation were modified to a nominal flow of 200 $\pm$ 50 cubic centimeters per minute (ccm).

   c. Record the rotameter flow from the front of the instrument. Reconnect the filter after the flow check is complete.

   d. Check the rate of the analyzer's "Sample" flow. Disconnect the ¼ inch Swagelok connection for the sample flow. This port is labeled "Sample" in the back of the instrument. Connect this port to the 1-liter or 3-liter flow standard. Record the MFM display. Determine the standard flow by using the certification equation for the flow standard. The nominal flow of this port is 700 ccm.

   e. Record the rotameter's flow from the front of the instrument. Reconnect the sample inlet line after the flow check is complete.

E.2.4 "As-is" Calibration

Follow these steps to perform the "as-is" calibration:

1. Initial Checks - Before performing an "as-is" calibration, ensure that the particulate filter on the sample inlet line has been recently changed. If not, replace it. Verify the analyzer has recently been electronically zero/span checked on all three channels.

2. Zero Calibration Checks

   a. Allow the gas dilution system to operate for at least 30 minutes with zero air flowing at 5-6 lpm.

   b. Use a timer/stopwatch to meter the time between calibration steps.

   c. Read and record the zero readings from the NO and NO_x channels of the data logger.

3. Span Calibration Checks - At the discretion of the person performing the instrument calibration, one of two procedures may be used. The selection of the appropriate procedure depends on the analyzer's response to the first point test span gas.

   a. Run one "as-is" calibration point at approximately 80% of the upper range limit (URL). Allow sufficient time for the analyzer response to stabilize. If the analyzer response is within ±5% of true and meets requirements listed in Table E.2.1, record the "as-is" results on the "as-is" calibration form. Indicate on the bottom of the raw datasheet that the response was within 10% of true for the initial 80% level. After the response of this first point has been recorded, the person doing the calibration should continue using procedure i or procedure ii (below) .

      i. If the analyzer is operating normally, previous nightly spans indicate no abnormality, and there are no other indications of malfunctions, the analyzer may be re-spanned to reflect the true gas concentration. To make a span adjustment, follow the instructions found in Section E.2.6, items 3 and 4.

      ii. If the analyzer is operating normally, a multi-point "as-is" calibration may be completed for the following steps 4a through f.

4. "As-Is" Calibration - Perform the instrument "as-is" linearity calibration by completing a multi-point calibration.

   a. Run four "as is" calibration points. Determine the calibration set points by the following formula:

$$\text{NO ppm} = (G \times C)/(G + A)$$

      Where:

      G = the flow of gas in ccm

      A = the flow of air in ccm

      C = the concentration, in ppm, of the NO gas standard

   b. These calibration points should be approximately 80%, 40%, 20%, and 10% of the URL. For example, if the full-scale output of the NO/NO_x analyzer is 1.0 ppm, 80% of the URL equals 0.80 ppm NO.

   c. Calculate the true NO and NO_x values from the cylinder and flow transfer standard certification numbers. Record on the datasheet.

   d. Read and record the instrument's output for the 80% URL level after 20 minutes or a stable reading is indicated on the chart recorder. Repeat this process for the 40%, 20%, 10%, and zero levels on the datasheet.

e. Calculate the slope and intercepts for the NO and NO_x data with the linear regression equation.

f. Determine the “as is change from previous calibration” for the NO and NO_x channels.

g. Mark the strip chart recorders with the type of calibration, date, and calibrator’s name. In addition, record the NO/NO_2/NO_x calibration in the station’s logbook.

E.2.5 Converter Efficiency

Read and record the converter efficiency (CE) from the previous calibration. This information can be obtained by pressing the “STAT” button until “CE XX.X” is displayed.

Perform the CE test with a value of 100.0 in the “CE XX.X” display. To determine the TECO 42’s CE, operate the gas calibration system near 70 ppm NO. The test will be conducted with the same plumbing configuration as in the “as-is” calibration; however, one of the dilution system manifold output ports will be connected to the ozone analyzer’s input port. Monitor the ozone concentration during the gas phase titration to ensure that all of the ozone is consumed in the reaction. The ozone concentration must be less than 90% of the NO concentration. Refer to CFR 40, Part 50, Appendix F, for a detailed explanation of the theory behind gas phase titration.

An alternate plumbing configuration is also acceptable. This alternative configuration does not connect the ozone photometer to the calibrator manifold. The alternate configuration can be used if prior experience has shown more than 10% of the NO concentration remains after the complete titration of the available ozone is stable. If prior experience with the calibrator shows all ozone being consumed during the titration and at least 10% NO is left, then note the set points for the mass flow controllers and the ozone generator that produced the desirable test points.

E.2.6 Zero/Span Correction

Correctly setting the baseline value, or zero, and the full scale, or span, value is critical. These set points allow the instruments to accurately and precisely measure pollutants within the range specified. The following steps will direct you in properly executing both zero and span adjustments.

1. Adjustments for Final Calibration - If the TECO 42 has been calibrated previously at this location, the “as is” calibration is within 5% of “true,” and if adjustments have not been made to the analyzer, the “as-is” calibration can be used as a “final” calibration. If the instrument is outside of these parameters, it must be set to zero and spanned before a final calibration can be performed (the troubleshooting guide in Table E.2.2 may be used as a reference for certain conditions to determine a possible malfunction).

2. Instrument Zero - The instrument must be in the “AUTO” mode. Run zero air, from the clean air package or an air purifier, through the gas calibration system for approximately 30 minutes or until a stable reading is achieved for 5 minutes. Press the “DISPLAY” button until “1” appears in the leftmost LED display (1 is the NO channel). Press the “CAL” button. Enter “0000” on the thumb-wheel. Press “ENTER.” Repeat this procedure for the NO_x channel (3).

3. NO Span - Set the TECO Model 146C or the API Series 700 mass flow multi-gas calibrators to 80% of the URL.

NO/NO2/NOx CHEMILUMINESCENT ANALYZER
CALIBRATION DATASHEET

Site Name: ____________ Calibration: As Is ☐ Final ☐
Site Number: ____________ Log Number: ____________
Date: ____________

PRIMARY DATA ACQUISITION SYSTEM (DAS) IDENTIFICATION

Make & Model: ____________ Prop. No.: ____________ Serial No.: ____________
Additional Information: ____________

NITRIC OXIDE CALIBRATION

Zero Setting: NO ______ NO2 ______ NOx ______ ; Span Settings: NO ______ NO2 ______ NOx ______

Transfer Standard					[NO] OUT (ppm)	[NOx] OUT (ppm)	NO			NOx		
NO Gas Flow		Dilution Flow		Total Flow			Chart	DAS	Net	Chart	DAS	Net
Display	sccm	Display	sccm	sccm			(%FS)	(ppm)	DAS	(%FS)	(ppm)	DAS
					Σ	Σ			Σ			Σ

Percent Deviation from True:

NO: $\left(\dfrac{\Sigma\ NO\ Net\ DAS}{\Sigma\ [NO]_{OUT}} - 1\right) \times 100\% = \underline{\qquad\qquad}\ \%$

NOx: $\left(\dfrac{\Sigma\ NOx\ Net\ DAS}{\Sigma\ [NOx]_{OUT}} - 1\right) \times 100\% = \underline{\qquad\qquad}\ \%$

Linear Regression: Analyzer Response (ppm), $NO, = \underbrace{(\underline{\qquad\quad})}_{Slope}\ ([NO]_{OUT}) \pm \underbrace{(\underline{\qquad\qquad})}_{Intercept}\ ppm$

Analyzer Response (ppm), $NOx, = \underbrace{(\underline{\qquad\quad})}_{Slope}\ ([NOx]_{OUT}) \pm \underbrace{(\underline{\qquad\qquad})}_{Intercept}\ ppm$

As Is Change From Previous Calibration Dated ____________________:

NO: $\left(\dfrac{As\ Is\ Slope - Old\ Slope}{Old\ Slope}\right) \times 100\% = (\underline{\qquad\qquad}) \times 100\% = \underline{\qquad\qquad}\ \%$

NOx: $\left(\dfrac{As\ Is\ Slope - Old\ Slope}{Old\ Slope}\right) \times 100\% = (\underline{\qquad\qquad}) \times 100\% = \underline{\qquad\qquad}\ \%$

Comments: ____

MLD-47 (11/89) Calibrated By ____________ Checked By ____________

Figure E.2.1. Calibration Datasheet (cont.)

Table E.2.1
"As-Is" Calibration Tolerances

ITEM	PARAMETER	TOLERANCES
Converter Efficiency	100%	> 96%
Converter Temperature	325 ºC	± 25 ºC
Zero Value	True Zero	± 0.5 divisions
NO/NO_x Value	True Value	± 5%
NO/NO_x Output	Spread Between Values	± 2 divisions
Sample Flow	700 ccm*	± 100 ccm
Ozone Flow	225 ccm	± 25 ccm
System Vacuum	760 mm mercury	> 725 mm mercury

*cubic centimeters per minute

Table E.2.2
Analyzer Troubleshooting Guide

NO_2/O_3 RATIO*	O_3 READING	NO_2 READING	PROBABLE CAUSE
Constant	Decreasing	Decreasing	CAL UV lamp output decreasing
Increasing	Decreasing	Constant	O_3 analyzer needs calibration
Increasing	Constant	Increasing	NO/NO_x analyzer needs calibration
Decreasing	Constant	Decreasing	Bad NO_2 converter or NO/NO_x analyzer needs calibration
Decreasing	Increasing	Constant	Malfunctioning O_3 analyzer

*nitrogen dioxide/ozone

Challenge the instrument with this level of gas for 30 minutes or until a steady trace is achieved for at least 5 minutes. The instrument must operate in the “AUTO” mode for at least 5 minutes with a stable reading. Observe the data logger value. Enter the calculated value for the NO concentration on the thumb-wheel (4 position set pot). The calculated NO value is based on the NO assay value, the gas calibrator’s gas certification value, and the gas calibrator’s air certification value. For example, a value of 0.8 ppm will be entered as “0800” on the thumb-wheel switch. Press the “CAL” button. The light above the CAL button will illuminate. Press the “DISPLAY” button until the leftmost LED display reads 1 (1=NO, 2=NO_2, 3=NO_x). Press “ENTER” and the NO channel set point will be reset to the calculated value for NO. Since the NO/NO_x calibration values tend to drift downward as time increases, it is desirable to set the thumb wheel setting at 2% higher than the calculated dilution values (e.g., if the concentration of NO has been calculated to be 0.782 ppm NO, set the thumb-wheel setting to 0.798 ppm NO).

4. NO_x Span - Repeatedly press the “DISPLAY” button until the number “3" appears in the leftmost LED display. The instrument must operate in the “AUTO” mode for at least 5 minutes with a stable reading. Press the “CAL” button. Observe the data logger value. Enter the NO_x concentration into the thumb-wheel switch. Press “ENTER” and the NO_x channel set point will be reset to the calculated value for NO_x.

E.2.7 Final Calibration

A final calibration must be performed if the instrument has been re-zeroed and re-spanned, had its CE changed by greater that 1.0%, or has had major maintenance performed. Fill out the final calibration form, or laptop computer form, as much as possible, then begin the actual calibration. Since the basic principle of operation of this sampler is the subtraction of NO from NO_x, it is not deemed necessary to calibrate the NO_2 channel. The final calibration steps are briefly summarized below.

1. Send zero air to the instrument through the gas dilution system. Record zero readings after 20 minutes of zero air or 5 minutes of stable zero readings. Run four final calibration points using the gas calibration system. These points should be at 80%, 40%, 20%, and 10% of the URL. Calculate the true NO and NO_x values from the cylinder and flow transfer standard certification numbers. Record this data on the datasheet. Read and record the instrument's output, from the data logger, for the 80%, 40%, 20%, and 10% levels.

2. Sum the net NO_x concentrations and record the data on the datasheet. Sum the net NO and NO_x data logger readings. Calculate the "percent deviation from true" for NO and NO_x. Record on the datasheet. Calculate the linear regressions for NO and NO_x. With the results from the previous calibration report, calculate the "as-is change from previous calibration" for the NO and NO_x data. Record these percentages on the datasheet. Note any worthy comments at the bottom of the datasheet.

3. Enable all appropriate data logger channels.

4. If the station zero air system is used, reconnect the zero air supply and set the pressure regulator to its pre-calibration setting.

5. Close the valve and turn off the compressed gas calibration cylinder.

6. Have the station technician initiate the nightly calibration dilution system and verify that the data produced are within acceptable limits.

7. Plot the results of the calibration using an acceptable spreadsheet program. Plot the "indicated" data logger readings on the y-axis and the "true" NO/NO_x concentrations on the x-axis.

STATS TABLE FOR CALIBRATION

Site Name: ______________________ Calibration: As Is ☐ Final ☐
Site Number: ______________________ Log Number: ______________________
Date: ______________________

DIAG/STATUS	INFORMATION	
1 F.SCALE	Full Scale ppb	
2 F.SCALE	Full Scale ppb	
3 F.SCALE	Full Scale ppb	
	Integrtn Time secs	
trb	Troubleshoot on/off	
cl	Cooler Temp ^oC	
ct	Converter Temp ^oC	
cc	RX Chamber Temp ^oC	
bl	NO Zero Backgrd	
b3	NOx Zero Backgrd	
S.F.	NO Span Factor	
b.f.	NOx Balance Fctr	
ce	Convert Efficiency %	
0	Analog Offset	
d IP	DIP Switch Status	
1 to 8	Dip Switches 1,2,3	
P	Program Number	
t	P/T on/off	
^oC	Internal Temp.	

Figure E.2.1. Calibration Datasheet; Statistical Data Table for Calibration

Calibration Report -- TECO 42 NO, NO2, NOx Analyzer

Calibration Report:

ID Information:

Station Name:	
Site #:	
Station Address:	
Agency:	

Instrument:

Make:	TECO
Model #:	42
Property #:	
Serial #:	
Log #:	

Calibration:

"As Is"	
"Final"	
Calib. Date	
Report Date	
Prev. Calib. Date	

Calibration Results:

		NO	NO2	NOx
Pollutant:		NO	NO2	NOx
Instrument Range, ppm:				
Previous Slope:				
Converter Efficiency (Avg.):				
Best Fit Line	Slope:			
	Intercept:			
	Correlation:			
"As Is" Deviation from True:				

Meteorology:

Temp. (Deg. C):	
Atm. Pres. (mm Hg):	
Elevation (ft):	

Data Acquisition System (DAS):

Make:	
Model #:	
Property #:	

Instrument Parameters:

Pollutant:	Ozone:	NO & NOx:
MFC Display:		
Flow Rate (slpm):		
Flow Setting:		
Delta Pres.:		
Rx Cham. Vac. (in Hg):		
Converter Temp. (C):		
Conv. Temp. Setting (C):		

Compressed Gas Cylinder:

Make & Model:	
I.D. #:	
NO Conc. (ppm):	
NOx Donc. (ppm):	
Cylinder Pres. (psi);	
Outlet Pres. (psi):	
Cert. Date:	
Cert. Exp.:	

Dilution Transfer Standard I.D.:

Make & Model:		Gas T. (C):	
Property No.:		Air Flow (v):	
Serial No.:		Gas Flow (v):	
Air Flow Setting:		P/T (on/off):	
Air Flow Rate (Display):		Cert. Date:	
Gas Pres. (mm Hg):		Cert. Exp.:	

Dilution Air:

Make & Model:	
Property No.:	
Outlet Pres. (psi):	

Transfer Standard Equation:

		m:	x:		b:	
Gas:	Gas Flow =		* Avg. Disp.	+/-		SCCM
Air:	Air Flow =		* Avg. Disp.	+/-		SCCM
MFC 0-30 lmp:	Air Flow =		* Avg. Disp.	+/-		SLPM
MFC 0-3 lpm:	Air Flow =		* Avg. Disp.	+/-		SLPM

Calibration Data:

Gas Dilution (Transfer Standard):

NO Gas Setting:	NO Gas Flow Display:	NO Gas Flow SCCM:	Dilution Flow Display:	Dilution Flow SCCM:	Total Flow SCCM:
0					
75					
35					
20					
10					
0					

Figure E.2.2. NO/NO_x Calibration Report (Computer Form)

Calibration Report -- TECO 42 NO, NO2, NOx Analyzer

NO Calibration Data (Instrument):

NO Out (x) ppm:	Chart % Full	DAS ppm	Net DAS (y)	Graph Values

Linear Regression Equation:

Net DAS=NO (out) x + b (ppm)	
x:	
b:	

Percent Deviation from True:

NO Net DAS vs NO Out:	

NOx Calibration Data (Instrument):

NOx Out (x)	Chart % Full	DAS ppm	Net DAS (y) ppm	Graph Values

Net DAS=NOx (out) x + b (ppm)	
x:	
b:	

Percent Deviation from True:

NOx Net DAS vs NO Out:	

NO vs. Net DAS Linear Regression Output:

Constant		
Std Err of Y Est		
R Squared		
No. of Observations		
Degrees of Freedom		
Correlation		
X Coefficient(s)		
Std Err of Coef.		

Slope % dif. As Is vs. Prev. Cal.:

NO:	
NOx:	

NOx vs. Net DAS Linear Regression Output:

Constant		
Std Err of Y Est		
R Squared		
No. of Observations		
Degrees of Freedom		
Correlation		
X Coefficient(s)		
Std Err of Coef.		

Comments:			
Calibrated by:		Checked by:	

Figure E.2.2. NO/NO_x Calibration Report (cont.)

Make:	TECO		Model:	42
Serial #:	See cover sheet		Date:	7/18/02
Diagnostics:	Description:	"As Is" Value:	"Final" Value:	Range:
	Full Scale	1000 ppb	1000 ppb	0-1000 ppb
	NO	1000	1000	0-1000 ppb
	NO2	1000	1000	0-1000 ppb
	NOx	1000	1000	0-1000 ppb
	Time Avg. Setting	300 sec.		300 sec
	Trouble-shoot	On		On/Off
cl.	Cooler Temp.	3.3		-3˚C +/- 1˚C
ct.	Converter Temp.	320		325˚C +/- 25˚C
r.c.	Reaction Chamber Temp.	49.5		50˚C +/- 1˚C
b1	NO Zero Background	0.3		2.9 to 3.5
b3	NOx Zero Background	1.5		3.2 to 3.6
S.F.	No Span Factor	1.005		1.0 to 3.999
b.F.	NOx Balance Factor	0.996		.96 to 1.04
ce	NO2 Converter Efficiency	100.0		96.0 to 100%
nr	Thumb-wheel Reading	Thumb-wheel	Thumb-wheel	Thumb-wheel
0	Analog Offset %	0		0
dip	DIP Switch Status			
	DIP #1 to #8 Display			
	Program Number			
	P/T	4258		
	Internal Temperature	On		On/Off
	Sample Pressure	34.9		Ambient +5˚C
	Input Board Offset			

Figure E.2.2. NO/NO_x Calibration Report (cont.)

Converter Efficiency Determination:

Ozone Set Point:	Ozone Off:			Ozone On:			Delta NO	Delta NOx	Converter Efficiency:
						Ave. Conv. Efficiency:			

COMMENTS:	NOTE: SINGLE POINT CE CHECK ONLY FOR AS-IS.			
Calibrated by:			CHECKED BY:	

Figure E.2.3. NO/NO_x Converter Efficiency (Computer Form)

APPENDIX F: SULFUR DIOXIDE ANALYZERS

STATE OF IDAHO

DEPARTMENT OF ENVIRONMENTAL QUALITY

AIR MONITORING QUALITY ASSURANCE

STANDARD OPERATING PROCEDURES

FOR

AIR QUALITY MONITORING

THERMO ELECTRON MODEL 43C SULFUR DIOXIDE ANALYZER

AND TELEDYNE API MODEL M100A SULFUR DIOXIDE ANALYZER

MODELING, MONITORING, AND EMISSIONS INVENTORY

JULY 2002

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TECO MODEL 43C AND API MODEL M100A SULFUR DIOXIDE ANALYZERS

FIGURES

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TECO MODEL 43C AND API MODEL M100A SULFUR DIOXIDE ANALYZERS

ACRONYMS, UNITS, AND CHEMICAL NOMENCLATURE

API	Advanced Pollution Instrumentation
DAS	data acquisition system
DEQ	Department of Environmental Quality
DVM	digital volt meter
ESD	Electrostatic Discharge
FEP	perfluoro (ethylene-propylene) copolymer
F_{SO2}	sulfur dioxide gas flow
Hg	Mercury
LCL	lower control limit
MFC	mass flow controllers
MSDS	material safety data sheet
NIST	National Institute of Standards and Technology
NO	nitrogen oxide
NO_2	nitrogen dioxide
PC	personal computer
PMT	photomuliplier tube
ppm	parts per million
SLPM	Standard liters per minute
SO_2	sulfur dioxide
SOP	standard operating procedure
TECO	Thermo Electron Corporation
UCL	upper control limit
UV	Ultraviolet
VAC	volts alternating current
VDC	volts direct current

REFERENCES

TECO MODEL 43C AND API MODEL M100A SULFUR DIOXIDE ANALYZERS

This standard operating procedure (SOP) references two different manufacturer's operating manuals for sulfur dioxide (SO_2) analyzers. One of the models is a Thermo Electron Corporation (TECO) Model 43C SO_2 Analyzer. This SOP references the TECO Model 43C instruction manual dated July 8, 1999. The other model is the Advanced Pollution Instrumentation (API) Model M100A SO_2 Analyzer. This SOP references the 1994 instruction manual for the API Model M100A. This document combines each of these model's operating manuals into a general SOP. When a specific analyzer is referenced, you will be referred to the appropriate manufacturer's instruction manual.

F.1 GENERAL INFORMATION

Sulfur dioxide (SO_2) is a criteria pollutant. Ambient air concentration limits are specified in the National Ambient Air Quality Standards (NAAQS). EPA required monitoring is required to verify compliance with the NAAQS.

F.1.1 Theory of Operation

The SO_2 analyzers measure the amount of fluorescence given off by SO_2 after its absorption of ultraviolet (UV) light. The fluorescent measurement is proportional to the SO_2 concentration. A detailed discussion of the scientific basis of each analyzer's measurement principle is contained in its manufacturer's instruction manual.

This document provides information supplemental to the manuals. Reference the individual manufacturer's manuals for instructions on servicing and troubleshooting. Separate sections below present acceptance test and calibration procedures for the API Model M100A and TECO Model 43C analyzers.

F.1.2 Analytical Cycle

The following description presents the flow and analysis of an air sample entering the analyzer's sample port (see Figure F.1.1).

The sample flows through the sample port to the tube side of the permeation dryer. Using the differential partial pressure of water and selective permeation, the dryer removes water without affecting the SO_2 concentration. Exiting the dryer, the sample flows through a pressure-reducing capillary and on through a hydrocarbon cutter. The cutter removes aromatic hydrocarbons, which fluoresce at the same wavelength as SO_2. The sample then enters the fluorescence chamber.

Filtered and pulsed UV light is focused through a UV interference filter into the chamber. In the chamber, the electron shells of the SO_2 molecules absorb the UV light, exciting their electrons to a higher energy level. After a brief period of time, the excited SO_2 molecules relax, giving off their characteristic decay radiation. A band-pass filter allows only this radiation to strike a photomultiplier tube (PMT), where it is converted into an electrical signal. The PMT output is modulated by a pre-amp which integrates the current and converts it to a voltage waveform. The signal then proceeds through an electronic gate to filter out high frequency noise. This gate is switched on synchronously with the UV light source. An adjustable time response filter is utilized to stabilize the signal before it is provided to the parts per million (ppm) meter and recorder output.

Calibration activities adjust the baseline, or zero reading, and span values measured by the instrument. To obtain a clean zero measurement, PMT output resulting from scattered UV light, background radiation detected with no SO_2 present, are suppressed using the zero pot. To obtain correct upper scale measurements, the PMT's high voltage or the final amplifier gain can be adjusted. These adjustments are performed after the instrument in properly zeroed. SO_2 concentrations in excess of 80% of full scale are used to exercise the instrument.

On leaving the chamber, the sample flows through the flow meter, the vacuum regulator, the shell side of the dryer, the sample pump, and out the exhaust. The vacuum regulator controls the absolute pressure in the chamber. The vacuum applied to the dryer shell is approximately 20 inches of mercury (Hg). For further details refer to the manufacturer's instruction manual.

F.1.3 Cautions

1. Light from this analyzer's UV lamp can burn the eyes. Use protective glasses to view the lamp or look at it only for less than a second at distances of 2 or more feet. Do not touch the lamp face.

2. The analyzer contains a 1000-volt direct current (VDC) power supply for the UV lamp, a -1000 to -2000 VDC power supply for the PMT, and 115 volt alternating current (VAC) at the input terminals to the PMT power supply. When working on this analyzer use all high voltage precautions.

3. High voltage is present in this analyzer. Use a third wire ground on this analyzer.

4. The hydrocarbon cutter contains a specified amount of fine light green catalyst material. Do not disassemble the cutter, as material may be lost.

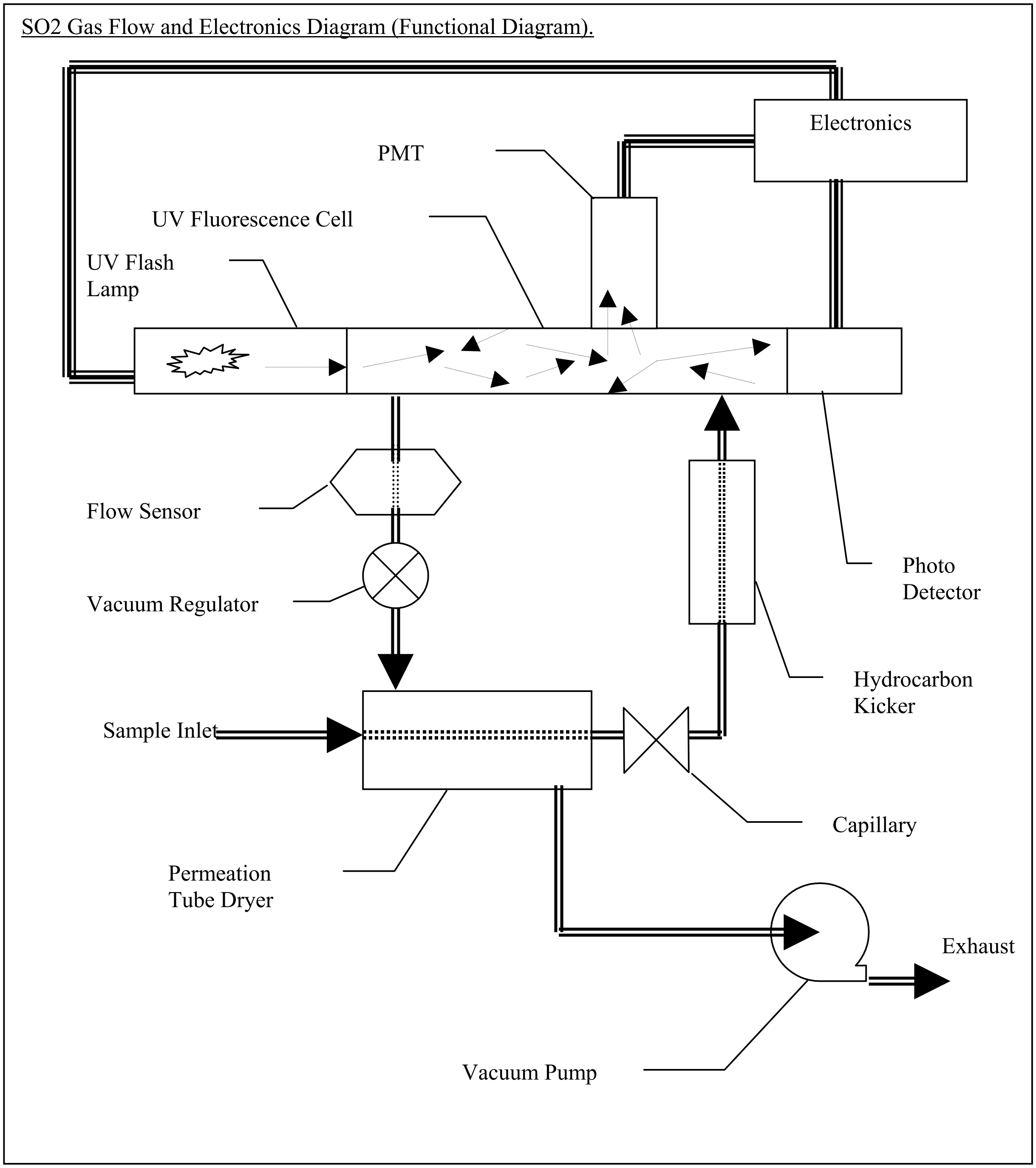

Figure F.1.1 SO_2 Analyzer Flow and Sensor Schematic Diagram

F.2 ROUTINE SERVICE CHECKS

F.2.1 General Information

Perform the following routine service checks using the attached schedule (Table F.2.1) and the procedures documented below. Checks may be performed more frequently than listed here, but should be performed at least at the prescribed intervals. Complete the Monthly Quality Control Maintenance Check Sheet (Figure F.2.1) weekly and submit it monthly to your supervisor.

F.2.2 Daily Checks

- Verify that the flow meter reads the correct flow as indicated on the most recent calibration report. Record the flow meter reading weekly.
- Verify that the mode selector switch is set at “SAMPLE”.
- Verify that the range selector switch is set to 0.5 ppm.

F.2.3 Weekly Checks

Record the “as found” and “final” readings on the Monthly Quality Control Maintenance Check Sheet.

- System Vacuum - Check that the gauge pressure indicates -10.0 inches Hg. Adjust if necessary.
- Leak Check - Perform a leak check of the analyzer using the procedure in Section F.3.1.
- Sample Inlet Particulate Filter - At least once a week, replace the Teflon® sample particulate filter. Note the filter cleanliness and adjust the replacement frequency accordingly. Change the filter if even a slight particulate coating or discoloration is visible.
- Scattered Light Level - Note the zero pot setting (when sampling zero air) and then turn the dial fully counterclockwise (000). Record the scattered light level, in parts per million, on the check sheet, and then return the zero pot to its initial setting. If the scattered light level is greater than 0.15 ppm, replace the UV interference filter.
- Zero and Span Check - Perform an analyzer zero and span check after the above weekly checks have been performed, using the procedures in Section F.3.3. At those sites without automatic daily calibration systems, complete the weekly portion of the check sheet. Record all parts per million values in the lower part of the appropriate blocks and the pot settings in the upper part of the appropriate blocks (see Figure F.2.1). At those sites with automatic calibrators, the SO_2 value is not to be recorded on the analyzer’s check sheet since it appears on the calibrator check sheet.

F.2.4 Monthly Checks

1. Capillary and O-Ring - Remove the glass capillary and rubber O-ring. Replace the O-ring if it is cracked and/or deteriorated. Push a thin wire through the

capillary to clear it of particles, then rinse the capillary with alcohol and let it dry. Reassemble the capillary and O-ring and record the date of these activities on the check sheet.

2. Electrical Span - Using the procedures in Section F.3.2, check the amplifier and output signal voltages. Adjust if necessary. Record the results and the date of the check on the check sheet.

3. Switch Positions - Check and record on the check sheet the positions of the response time switch (SW1) and PMT high voltage coarse gain switch. SW1 should be set to the center position (four minute time response). The PMT voltage switch should be set in the position indicated on the most recent calibration report.

4. Multi-point Calibration - Monthly, record the date a multi-point calibration was last performed on the analyzer. Before six months have passed since the last analyzer calibration, contact your supervisor to arrange for a multi-point calibration.

F.2.5 Semi-Annual Checks

Check the cooling fan and filter twice each year. Remove the screws holding the metal filter screen to the rear panel. Remove the screen and soak it in a weak detergent solution to remove all particles. Rinse with clean water and air dry. Wipe the residue from the rear fan face with a clean cloth. Reassemble and record the date cleaned on the check sheet.

F.2.6 Annual Checks

Brominated charcoal is used for generating zero air used in zeroing the analyzer. The brominated charcoal contents must be replaced once a year. Upon receipt of the new filter, return the old filter unit to the supplier, accompanied by the appropriate paperwork, including the material's Material Safety Data Sheet (MSDS). Affix a date sticker, with the replacement date, to the new filter.

F.2.7 Eighteen-Month Checks

Replace the hydrocarbon cutter every 18 months. Upon receipt of the new cutter, return the old cutter to the supplier, accompanied by the appropriate paperwork, including the material's MSDS. Affix a date sticker, with the replacement date, to the new cutter.

Table F.2.1
TECO Model 43 and API Model 100A SO_2 Analyzer Service Schedule

	Daily[a]	Weekly	Monthly	Quarterly	Semi-Annually	Annually	18 Months
Sample Flow	X						
System Vacuum		X					
Leak Check		X					
Sample Inlet Particulate Filter		X					
Scattered Light Level		X					
Zero and Span		X					
Monthly Checksheet		X	X				
Capillary and "O" Ring			X				
Electrical Span			X				
Switch Positions			X				
Cooling Fan and Filter					X		
Multipoint Calibration[b]					X		
Replace Zero Filter						X	
Replace H.D. Cutter							X
Replace U.V. Interface	As Required						
Replace U.V. Lamp	As Required						
Replace Sample Pump	As Required						

[a] Or each day the operator services the analyzer
[b] Or as required after specific repairs listed in Troubleshooting, Section F.4.

IDAHO DEPARTMENT OF ENVIRONMENTAL QUALITY
MONTHLY QUALITY CONTROL MAINTENANCE CHECKSHEET
TECO MODEL 43 & API MODEL 100A SO_2 ANALYZERS

Location:________________________________ Month/Year:_______________________
Station Number:__________________________ Technician:_________________
____
Analyzer Property Number:_________________ Agency:__DEQ ________________

Date	Reading: Dial/Chart (ppm)				Sample Flow Setting	System Vacuum (" Hg)	Scattered Light Level (ppm)	Leak Check (*)	Replace Particulate Filter
	Zero		Span						
	As Found	Final	As Found	Final	As Found	Final			

*Requires multi-point calibration after this operation.

SO_2 Compressed Gas Cylinder Number______________ Concentration_______ppm.

Operator Instructions:

1) Daily Checks:
   a) Air flow (record weekly);
b) Mode switch on sample;
c) Check chart traces.
2) Weekly Checks:
   a) Check system vacuum;
   b) Leak check;
   c) Zero and span;
   d) Replace particulate filter;
   e) Check scattered light level.
3) Monthly Checks:
   a) Inspect capillary and O-ring: Date last inspected:___________.
   b) Check electrical spans: Date last checked:____________.
   c) Amplifier output: As found _____________ V; Final __________ V.
   d) Signal output: As found _____________ mV; Final __________ mV.
   e) Switch positions: PMT (L M H); Response time (LEFT CENTER RIGHT).
4) Semi-Annual Checks:
   a) Clean cooling fan and filter: Date last cleaned: ____________.
   b) Calibration: Date last calibrated:___________.
5) Annual Checks: Replace zero filter. Date last replaced:____________.
6) 18 Month Check: Replace hydrocarbon cutter. Date last replaced:____________.

Date	Comments or Maintenance Performed

Reviewed By:___________________________________ Date:_______________

Figure F.2.1 Monthly Quality Control Maintenance Check Sheet

F.3 DETAILED MAINTENANCE AND ADJUSTMENT PROCEDURES

F.3.1 Leak Checks

Place the mode selector switch on “ZERO.” With a Swagelok plug, cap the bulkhead zero input port. Wait two minutes. The flow meter should now read zero. If the flow meter shows flow there is a leak present. Inspect all lines for breaks and verify that all fittings are tight. Isolate the leak and replace any valves or fittings as necessary. Remove the plug from the zero port and place it on the span port. Place the mode selector switch on “SPAN” and check as above. Remove the plug from the span port and place it on the sample port. Place the mode selector switch on “SAMPLE” and check as above.

F.3.2 Electrical Span Adjustments

Allow the analyzer to warm up for at least one hour prior to performing any adjustments, calibrations, or functional checks.

1. Amplifier Personal Computer (PC) Board – Obtain access to the electronic section and expose the printed circuit boards (refer to the analyzer’s operating manual). Locate the full-scale pot and calibrate toggle switch on the amplifier board and make adjustments as follows:

    a. Attach a digital voltmeter between the 10-volt output terminal on the output PC board and ground.

    b. Place the amplifier board’s calibrate toggle switch in the “FULL SCALE” position.

    c. Record the “as found” digital volt meter (DVM) voltage on the check sheet. Then, if necessary, adjust the full-scale pot until the DVM indicates 10 ± 0.01 volts. Record the final DVM voltage on the check sheet.

    d. Return the calibrate toggle switch to the “OPERATE” position.

2. Output PC Board - After performing the above, adjust the 1 volt signal output as follows:

    a. Verify that the jumper wire on the output PC board is connected from the center terminal position to 1 volt.

    b. Put the calibrate switch in the “FULL SCALE” position.

    c. Adjust the “METER ADJUST” pot so that the front panel PPM meter is at full scale.

    d. Attach the digital voltmeter leads to the recorder output terminals at the rear of the analyzer.

    e. Record the “as found” reading on the check sheet. If necessary, adjust the “METER ADJUST” pot so that the DVM reads 1.000 ± 0.001 volts. Record the “final” reading on the check sheet. Check that the strip chart recorder indicates the same value as the DVM. If the difference is greater than 0.5%

of full scale (½ chart division) check the recorder and/or the recorder leads and make corrections as required.

f. Return the calibrate switch to the ”OPERATE” position.

NOTE: If a digital voltmeter capable of 1 volt is not available, use the strip chart recorder.

F.3.3 Analyzer Zero And Span Checks

This section describes the procedure for performing analyzer zero and span checks and adjustments. Adjustments of analyzer zero and span settings are made whenever the specified control limits are exceeded. Flash lamp deterioration with time causes decreased analyzer sensitivity of 1 to 2% per week. Sudden shifts in zeros and spans should be thoroughly investigated, and your supervisor notified before any span and zero adjustments are made. In the event the specified control limits are exceeded and zero and span adjustments are required, they shall be performed after the monthly checks in Section F.2.4 are repeated.

To maintain the analyzer within acceptable calibration tolerances it is necessary to establish upper and lower control limits. Exceeding the upper control limit (UCL) necessitates troubleshooting the analyzer as the problem is most probably caused by an analyzer malfunction. Exceeding the lower control limit (LCL) generally represents flash lamp decay and only necessitates resetting the analyzer span. For satellite stations, reset the span if the "as found" span reading is more than 10% below the true SO_2 concentration. Mathematically, the control limits are calculated as follows:

For satellite stations:
UCL, ppm, = 1.10 x True Concentration
LCL, ppm, = 0.90 x True Concentration
Given: True SO_2 Concentration = 0.40 ppm
Calculate: UCL, ppm
LCL, ppm
UCL = 1.10 x 0.40 = 0.44 ppm
LCL = 0.90 x 0.40 = 0.36 ppm

F.4 TROUBLESHOOTING

F.4.1 General Information

Both analyzers' instruction manuals contain information pertaining to troubleshooting and should be your first source of information. Additional information on common problems is outlined below. Space is provided on the Monthly Quality Control Check Sheet for recording malfunctions, causes, repairs, and actions taken to prevent recurrence.

NOTE: Cautions listed in Section F.1.3 should be observed while performing troubleshooting and maintenance on the analyzer. Additionally, troubleshooting and repairs must not be performed on any electronic device without properly worn and grounded electrostatic discharge (ESD) straps.

F.4.2 Electronic Malfunctions

Table F.4.1 provides a quick reference to identify possible causes of electrical/electronic problems experienced while operating the SO_2 analyzers. Potential corrective actions are also provided. It is recommended that the specific analyzer's operators manual be consulted while attempting to troubleshoot and correct any problems encountered during instrument operation.

Table F.4.1
TECO Model 43 and API Model 100A SO_2 Analyzer Electronic Malfunction Troubleshooting Table

PROBLEM	PROBABLE CAUSE	FIX
Negative zero	Dirty UV[a] Lamp	Wipe clean with alcohol
Erratic zero	Defective shock mount on sample pump	Replace shock mount
	Flash lamp power supply providing out of specification power.	Replace flash lamp power supply[b]
	Defective PMT[c] high voltage power supply	Replace PMT[c] high voltage power supply[b]
Blows fuse	Flash lamp power supply drawing too much current	Replace flash lamp power supply and fuse[d]
Noisy output	Defective 15 VDC[e] supply	Replace power supply[b]
No PMT[c] output and cannot zero meter	Defective PMT[c]	Replace PMT[c]
Abrupt zero shifts	Dirty connector contacts	Clean contacts by disconnecting and then reconnecting the connectors[f]
	Defective permeation dryer	Replace dryer
High positive zero drift	Defective UV[a] interference filter	Replace UV[a] interference filter[a]
High negative span drift	Defective flash lamp	Replace flash lamp[d]
Sudden positive zero and span shift	1,000 volt lamp pwer supply defective resulting in high voltage to UV lamp	Replace lamp power supply[b]
Zero reading higher than recent ambient concentrations	Charcoal zero filter faulty	Replace zero filter[f]
	Interference flange not properly coated	Replace interference filter flange[b]

a Ultraviolet
b Requires multi-point calibration after this operation.
c Photomultiplier Tube
d Requires span check after this operation. If the span check indicates a response change of more than 10%, a multi-point calibration must be performed.
e Volts, direct current
f Perform a zero check.

23.5

F.4.3 Flow Malfunctions

Table F.4.2 provides a quick reference to identify possible causes of flow problems experienced while operating the SO_2 analyzers. Potential corrective actions are also provided. It is recommended that the specific analyzer's operators manual be consulted while attempting to troubleshoot and correct any problems encountered during instrument operation.

Table F.4.2
TECO Model 43 and API Model 100A SO_2 Analyzer Flow Malfunction Troubleshooting Table

PROBLEM	PROBABLE CAUSE	FIX
Zero/span solenoid valve leaking, or no flow	Defective zero/span solenoid valve	Replace solenoid valve[a]
Zero SO_2 output when monitoring ambient air	Pump stopped	Check the power to pump and change the pump if necessary[b]
	Output PC board out of socket	Reinstall output PC board if necessary[b]
Flow meter reading decreases weekly, or slow analyzer response	Leak in sample solenoid	Replace solenoid valve[a]
	Cutter clogged	Replace cutter[b]
	Capillary clogged	Clean the capillary[b]
	Faulty pump	Reset vacuum pressure or change the pump if necessary[a]
	Faulty inlet particulate filter	Replace inlet filter[b]

[a] Requires multipoint calibration after this operation.
[b] Requires span check after this operation. If the span check indicates a response change of more than 10%, a multipoint must be performed.

F.5 ACCEPTANCE TEST PROCEDURES

F.5.1 General Information

Before beginning acceptance testing of the analyzer, read the manual thoroughly. Then, initiate an instrument log book and an Acceptance Test Mini-Report (Figure F.5.1).

F.5.2 Physical Inspections

Unpack the analyzer and check for physical damage. Remove the top cover from the analyzer and perform the following checks:

NOTE: Prior to touching any electronics, properly ground yourself to the analyzer's housing to prevent ESD damage to the circuit cards.

1. Pull out the electronics drawer; extract and reinsert the printed circuit boards.

2. Check for correct power cord phasing. Standard wiring configuration has the black wire connected to the brass terminal of the plug, white to copper, and green to earth ground. Verify the analyzer chassis is grounded to earth ground.

3. With the analyzer power on, and observing the flow meter at the front of the analyzer, leak check the entire flow system using the procedure outlined in the analyzer's instruction manual.

4. Verify that the analyzer is complete upon receipt. (i.e., manuals, rack mount slides, etc. are included).

F.5.3 Operational Tests

Perform the following operational checks and record the results on the strip chart and mini report.

1. Electronics and Gas Flow

   a. Connect the power cord to the analyzer and turn on the power. Place the input mode switch on "ZERO" and the range PPM switch to 0.5 ppm. Access the electronics and locate the toggle switches on the PC boards (refer to the analyzer's operating manual for diagrams). Switch the toggles to verify that the full scale values and the time responses are set to acceptable ranges. The front panel meter should display these full scale readings and time response values. Return the toggle switches to the operating positions.

   b. With the power switched on, verify that the cooling fan, pump, and lamp are now operating. Using a 0-3 standard liters per minute (SLPM) flow meter, verify that the flow through the sample port is approximately 1.0 SLPM. Measure the air flow through the zero and span ports as well. Sequentially select the zero and span ports and verify that the flow through the each of these ports is 1.0 SLPM or identical to the flow through the sample port. Return the analyzer's valve body to the sample port selection.

   c. Verify that the vacuum reading on the pressure gauge is -10 inches Hg. If necessary, adjust the pressure regulator so that the gauge indicates a 10 inch Hg vacuum.

   d. Zero and span the analyzer using the procedure outlined in Section F.3.3.

2. Zero and Span Drift

   a. Establish stable zero and span (~0.4 ppm SO_2) traces on a strip chart recorder using appropriate repeatable sources.

   b. At intervals of 24 hours and 72 hours, repeat the above zero and span points. Deviations should not exceed ±1% full scale for 24 hours or ±2% full scale for 72 hours.

3. Voltage Variation Test -

   While sampling a constant concentration (~0.4 ppm SO_2), vary the input line voltage as indicated. Remain at each voltage for at least 10 minutes. Analyzer response changes due to voltage variations should not exceed ±0.01 ppm. Use the following input line voltages:

   a. 105 VAC
   b. 110 VAC
   c. 115 VAC
   d. 120 VAC
   e. 125 VAC
   f. 120 VAC
   g. 115 VAC

4. Temperature Variation - Place the analyzer in the environmental chamber. Establish a stable recorder trace. Vary the ambient temperature from 4 ºC to 44 ºC in 5 ºC

5. increments. Maintain the environmental chamber at each temperature increment for sufficient time to stabilize the analyzer at the new temperature (15 to 30 minutes). Analyzer response changes due to temperature variation must be less than ±0.01 ppm for zero air and less than ±0.03 ppm for sample concentrations concentration (~0.4 ppm SO_2).

    a. Establish a stable recorder trace utilizing a known concentration (~0.4 ppm SO_2). Process the instrument through the temperature cycle.

    b. Repeat the test while sampling zero air. Process the instrument through the temperature cycle.

6. Flash Lamp Supply Voltage - Check as follows:

    a. Turn off the analyzer.

    b. Remove the timing PC board.

    c. Carefully remove the flash lamp from the socket.

    d. Turn the analyzer power on.

    e. Check the voltage differential between socket pin #6 and the grounded chassis. The voltage differential shall be within the range +1000 VDC to +1035 VDC.

    f. Turn off the analyzer.

    g. Reinsert the flash lamp and timing PC board.

7. With analyzer power on, check the low voltage power supply for +15 VDC +0.2 VDC and -15 VDC +0.2 VDC.

8. Measure the scattered light level using the procedures identified in the applicable analyzer's instruction manual.

9. Calibrate the analyzer using National Institute for Standards and Technology (NIST) SO_2 permeation tubes or a certified multi-gas calibration system. Record the percent full scale deviation from true SO_2 concentrations at 80%, 60%, 40%, and 20% of full scale on the Acceptance Test Mini-Report (Figure F.5.1) and on the appropriate calibration form.

10. Check the PMT high voltage. Consult the applicable analyzer's operating manual for safety precautions. The following procedure provides the general sequence of operations.

    a. Turn off the analyzer.

    b. Remove the high voltage cable from the PMT housing.

c. Turn the analyzer power on.

d. Measure the voltage at the high voltage cable to chassis ground. The voltage should be -1000 VDC to -2000 VDC.

e. Turn off the analyzer. Short the PMT control terminals on the PMT voltage supply. Turn the analyzer power on. The voltage from the high voltage cable to chassis ground should now be greater than -2000 VDC.

f. Turn off the analyzer and remove the short.

g. Reconnect the high voltage cable to the PMT.

11. Install a pre-tested particulate filter holder on the sample inlet port. (Particulate filters must be tested to assure that they do not remove SO_2 from the sample stream.)

12. If the tests are satisfactory, record pertinent information such as flash lamp voltage, PMT high voltage, scattered light level, zero and span settings, etc. in the log book and on the mini report. The analyzer is now ready for field use.

TECO MODEL 43 & API MODEL 100A SO_2 ANALYZERS
ACCEPTANCE TEST "MINI REPORT"

Date________________________ Serial No._______________ Reviewed By_________________________ ARB No._______________ Date of Acceptance_______________

		Passed	Failed	Final OK
I.	Physical Inspection			
	A. Checked for shipping damage	_____	_____	_______
	B. Checked all electrical wiring	_____	_____	_______
	C. Checked all Plumbing for leaks	_____	_____	_______
	D. Analyzer complete upon receipt	_____	_____	_______
III.	Operational Checks			
	A. Checked operation of valves, controls, meters,			
	B. pumps switches indicator lamps, etc.	_____	_____	_______
	C. Set electrical zero and span	_____	_____	_______

		%FS Dev.	Range	Pass	Fail	Final OK
IV.	Tests Performed (Attach Charts)					
	A. Voltage variation (105 VAC to 125 VAC @.40 ppm)	_______	_____	___	___	_______
	B. 24 Hour Zero Drift	_______	_____	___	___	_______
	C. 24 Hour Span Drift @ .40ppm	_______	_____	___	___	_______
	D. 72 Hour Zero Drift	_______	_____	___	___	_______
	E. 72 Hour Span Drift @ .40 ppm	_______	_____	___	___	_______
	F. Linearity (%FS Dev. from true SO_2)					
	80% Full Scale:__ppm	_______	_____	___	___	_______
	60% Full Scale:__ppm	_______	_____	___	___	_______
	40% Full Scale:__ppm	_______	_____	___	___	_______
	20% Full Scale:__ppm	_______	_____	___	___	_______
	G. Temperature Variation					
	Zero Shift:					
	Step 1___ºC to___ºC	_______	_____	___	___	_______
	Step 2___ºC to___ºC	_______	_____	___	___	_______
	Step 3___ºC to___ºC	_______	_____	___	___	_______
	Span @ 0.40 ppm					

Step 1___ºC to___ºC ________ ______ ___ ___ ________

Step 2___ºC to___ºC ________ ______ ___ ___ ________

Step 3___ºC to___ºC ________ ______ ___ ___ ________

H. Final Analyzer Readings

Flash lamp voltage _______; Low voltage supply _______VDC; _______VDC

PMT High Voltage _______VDC; w/o control _______VDC

Flow: _______ SLPM@ _______Flow setting PMT switch: Low (Medium) High

IV. Special Tests

V. Comments/Maintenance Performed: ____

____

____

*III G: No shift at zero up to 35ºC; shift starts at -37ºC.

Figure F.5.1 Acceptance Test Mini-Report

F.6 CALIBRATION PROCEDURES

F.6.1 Introduction

DEQ calibrates SO_2 analyzers using a precise quantitative dilution of a compressed cylinder of SO_2 gas. The compressed gas cylinder of SO_2 is diluted with zero air and has a concentration in the range 20 to 50 ppm. Zero air is mixed with the SO_2 using a calibrated dilution apparatus to provide five concentrations from 0 to 90% of the analyzer's operating range. The SO_2 standard is initially certified against a NIST standard reference method (either cylinder gas or permeation source) and thereafter recertified at six month intervals. The dilution apparatus (mass flow meters, etc.) are also certified and recertified every three months against laboratory flow standards. See Appendix K, Multi-Gas Calibration System, for further details.

F.6.2 Apparatus

Refer to the applicable analyzer's instruction manual for a typical SO_2 dynamic calibration system schematic. Connections between components in the calibration system downstream from the SO_2 cylinder should be of glass, FEP Teflon®, or other nonreactive materials. The following items will be necessary to correctly complete calibrating the SO_2 analyzer.

1. Dilution Apparatus - Two calibrated mass flow controllers (MFC), two digital panel meters, and manual or solenoid valves for positive gas shut-off.

2. SO_2 Standard – A compressed gas cylinder containing 20 to 50 ppm SO_2 in oxygen free nitrogen with less than 0.005 ppm hydrogen sulfide; less than 0.005 ppm oxides of nitrogen (NO plus NO_2); less than 1.0 ppm (each) of total hydrocarbons, carbon monoxide, and carbon dioxide; and having a maximum dew point of –408 °C. The cylinder must be traceable to a NIST SO_2 standard reference method.

3. Zero Air - Air, free of contaminants that cause a detectable response on the SO_2 analyzer or that might react with SO_2.

4. Tubing - One-quarter or one-eighth inch FEP Teflon® tubing for airflow connections. All fittings in contact with SO_2 must be made of 316 stainless steel, FEP Teflon®, or Kynar® (polyvinylidene fluoride, PVDF).

5. Dynamic SO_2 Calibration Datasheet (Figure F.6.1).

IDAHO DEPARTMENT OF ENVIRONMENTAL QUALITY
DYNAMIC SO_2 CALIBRATION DATASHEET

Site Name:____________________ Calibration: As Is________ Final____
______
Site No:________________ Date:_____________ Log No:___________
______
Site Temp:________Barometric Pressure:___________ Site Elevation:_____
______

INSTRUMENT: Make & Model:______________ Property No:_____________
______
Serial No:______ Span:____ Zero:____ Range:_____ Airflow:______@___
sclpoint
Reaction Chamber Vacuum:___________″Hg Electronic Span:_________Full Scale.
Primary DAS: Make & Model:__________ Property No:__________ Serial No:____
______

TRANSFER STANDARD: Make & Model:_______________ Property No:________
______
Serial No:__________ Date Certified:_______________ Cert. Expires:___________
______
0-100 sccm MFC: Airflow = __________________ X Display ± ______sccm (SO_2 gas)
0-10 slpm MFC: Airflow = _____________ X Display ± ____________sccm(dilution)

COMPRESSED GAS CYLINDER: Cylinder No:_______ Property No:______ Assay_
ppm
Date Certified:___________ Cert. Expires:___________ Outlet Pressure:_________psi

DILUTION AIR: Source:_________ Property No:____________ Outlet Pressure:___psi

Transfer Standard					$[SO_2]_{OUT}$ (ppm)	Instrument		
SO2 Gas Flow		Dilution Flow		Total Flow		Chart (%FS)	DAS (ppm)	Net DAS
Display	sccm	Display	sccm	sccm				
				□			□	

Percent deviation from true: $\left(\frac{\Sigma SO_2\ Net\ DAS}{\Sigma[SO_2]_{OUT}}\right)X\,100\% = \left(\frac{\quad}{\quad}-1\right)X\,100\% = \qquad \%$

Linear regression: Analyzer response (ppm) = $\frac{(\quad)}{Slope}\left([SO_2]_{OUT}\right) \pm \frac{(\quad)}{Intercept}\ ppm$

As is change from previous calibration, dated_______________:

$\left(\frac{As\ Is\ Slope - Old\ Slope}{Old\ Slope}\right)X\,100\% = (\qquad\qquad)X\,100\% =$ _______________

Comments:____
______
____
______
____
______

Calibrated by:__________________ Checked by:__________________

Figure F.6.1 Dynamic SO_2 Calibration Datasheet

F.6.3 "As-Is" Calibration

Other than routine daily checks, analyzer repairs or adjustments should not be made prior to the "as-is" calibration. Follow the steps below to perform the "as-is" calibration.

1. Record analyzer parameters and site conditions on the Dynamic SO_2 Calibration Datasheet (Figure F.6.1).

2. Remove contaminants from the SO_2 pressure regulator:

   a. Purge the regulator and delivery system with SO_2 to a safe vent after opening the cycling valve.

   b. If possible, leave the regulator on the cylinder between calibrations (only if there is no transport involved).

3. Select the correct SO_2 operating range. Perform the appropriate analyzer electronic checks as outlined in Section F.3.2.

4. Using FEP Teflon® tubing, connect the SO_2 and zero air to the appropriate inlet fittings on the calibrator.

5. Disconnect the analyzer's sample probe at the station's sampling manifold and connect it to the outlet manifold of the dilution apparatus. Cap the open port on the station's sampling manifold.

6. If using a zero air cylinder, attach and flush the zero air regulator, being careful not to introduce contamination.

7. Once the dilution air flow rate is chosen, determine the required flow of SO_2 gas to obtain approximately 90% of full scale. Use the following equation and those provided with the mass flow meter transfer standards. Record the mass flow meter equations on the Dynamic SO_2 Calibration Datasheet. Do not adjust either MFC to less than 10% of full scale.

$$F_{SO_2} = \frac{(C_0)(F_a)}{C_{cyl} - C_0}$$

Where: F_{SO2} = SO_2 flow, standard cubic centimeters per minute
F_a = Air flow, standard cubic centimeters per minute
C_{cyl} = compressed SO_2 cylinder concentration, ppm
C_0 = desired concentration (diluted SO_2 concentration, ppm)

8. Turn the mode switch on the front panel to "SAMPLE." Open the air regulator outlet valve on the dilution apparatus; set the flow so that when the SO_2 gas flow rate is at its maximum, the diluted SO_2 concentration is calculated to be approximately 90% full scale. The total flow must exceed the total demand of the analyzer(s) connected to the calibrator's output manifold to insure that no ambient air is pulled into the manifold vent (see caution note below). Allow the analyzer to sample zero air until a stable zero response is obtained. Adjust the

analyzer's zero control to obtain the required zero set point on the chart recorder and again allow the analyzer to stabilize. Obtain approximately 10 minutes of stable recorder trace and record the response on the Dynamic SO_2 Calibration Datasheet.

CAUTION: Vent or scrub the excess SO_2 from the outlet manifold to the outside using a large diameter vent line.

9. Adjust the SO_2 gas flow (F_{SO2}) to the value calculated in Step 7 with the MFC potentiometer set to obtain approximately 90% full scale. It may require an hour or more for the reading to stabilize as the MFC, dilution apparatus, and analyzer must be conditioned to the calibration gas.

10. After the recorder chart response has stabilized, record the MFC displays and calculate actual standard cubic centimeters per minute for the SO_2 gas flow, dilution air flow, and recorder chart response on the Dynamic SO_2 Calibration Datasheet.

11. Reset the SO_2 MFC potentiometer to obtain responses of approximately 50%, 20%, and 10% of full scale. After the analyzer has stabilized for each test point, record the MFC displays and calculate actual standard cubic centimeters per minute and the corresponding recorder chart response on the Dynamic SO_2 Calibration Datasheet.

12. Repeat the zero reference point (Step 8). Allow the zero trace to stabilize on the recorder chart. The zero response should reproduce the original zero to within 1% of full scale. If it does not, determine the cause and correct the problem before continuing (refer to Section F.4.2, Electronic Malfunctions).

13. Perform the following calculations:

NOTE: The calculations assume that the SO_2 analyzer is linear (i.e., the calibration curve of the net chart recorder versus concentration is a straight line within 1% of full scale at each point.) If it is not, troubleshoot the analyzer and calibration system and correct the problem before continuing.

a. Calculate the SO_2 and dilution air flow rates, in standard cubic centimeters per minute , using the certification equations provided.

b. Using the flow rates calculated for Steps 7 and 11, in standard cubic centimeters per minute, calculate the true SO_2 concentration for each calibration point. Record under "[SO_2] " on the Dynamic SO_2 Calibration Datasheet.

True SO_2 concentration (ppm) = $\dfrac{C_{cyl} \times F_{SO2}}{F_{SO2} + F_a}$

c. Determine the net data acquisition system (DAS) response in parts per million by subtracting the average DAS zero response.

d. Calculate the deviation from true:

% Dev = $\dfrac{\lfloor SO_2 \;\; Net\, DAS - 1 \rfloor}{[SO_2]_{OUT}} \times 100\%$

Where Net DAS = Net Data Acquisition System

NOTE: Retreive the raw data for the above equations from the Dynamic SO_2 Calibration Datasheet.

e. Calculate the least squares linear regression coefficients (slope and intercept) using all calibration points including zero points and record on the Dynamic SO_2 Calibration Datasheet.

$$y = mx + b$$

where x = true SO_2 concentration, ppm = $[SO_2]_{OUT}$
y = Net DAS, ppm
m = slope (unitless)
b = y intercept, ppm

f. Calculate the "as-is" change from the previous calibration:

$$\frac{\text{As-Is Slope - Old Slope}}{\text{Old Slope}} \times 100\%$$

g. Plot the SO_2 calibration curve, Net DAS, or net chart versus $[SO_2]_{OUT}$.

h. If the slope, m, is between 0.95 and 1.05, and b agrees with the zero reading within 1% of full scale, then the analyzer is in calibration and no further adjustments are needed.

F.6.4 Final Calibration

If the slope, m, calculated in Step 13e is less than 0.95 or greater than 1.05, an adjustment and final calibration are necessary. Adjust the SO_2 analyzer to correct the deviation as follows:

1. Repeat the 90% of full scale span concentration (Section F.6.3, Steps 9 and 10).

2. Adjust the front panel span pot until the analyzer reads the true SO_2 concentration.

NOTE: Increasing the span pot increases the analyzer's response. Decreasing the span pot decreases the analyzer's response.

3. Repeat the zero reference point (Section F.6.3, Step 8), readjusting the front panel zero control as necessary.

4. Repeat Steps 1 through 3 in this section until no further adjustments are needed.

5. Repeat calibration points (90%, 50%, 20%, and 10% of full scale) for the final calibration. Complete the Dynamic SO_2 Calibration Datasheet and a calibration curve.

6. If there is insufficient range in the span control potentiometer to set the span, perform the following adjustments:

   a. Adjust the amplifier PC board and the output board. Refer to the analyzer's instruction manual for diagrams and refer to Section F.3.2, *Electrical Span Adjustments*.

   b. Verify that the pressure indicated on the pressure gauge inside the front panel is at -10 inches Hg. If it is not, check the capillary (refer to Section F.2.4), then adjust the regulator to obtain this value. This should be completed with the analyzer set to "SAMPLE."

c. Locate the printed circuit card that has the three-position toggle switch (M-L-H) for high voltage course adjustment of the PMT and a high voltage potentiometer for fine gain adjustment. Refer to the analyzer's instruction manual for diagrams.

   i. Adjust the front panel span control to a setting of 300.

   ii. Repeat the 90% full scale span concentration (Section F.6.3, Steps 9 and 10). Adjust the high voltage potentiometer so the analyzer obtains the true SO_2 concentration ±0.010 ppm.

   iii. If the adjustment of the high voltage potentiometer does not bring the analyzer within the true SO_2 concentration ±0.010 ppm, put the high voltage toggle switch in a higher (or lower) position and repeat Step ii.

d. Repeat the zero reference point. Re-adjust the front panel zero control until the analyzer is zeroed.

e. Repeat Steps c and d until the true SO_2 concentration and a good zero reading are obtained.

f. Adjust the analyzer's front panel span control until the SO_2 response is exactly the concentration being supplied.

g. Repeat the calibration points for the final calibration (0 to 90% of full scale), completing a Dynamic SO_2 Calibration Datasheet and a calibration curve.

7. If the analyzer span still cannot be adjusted to provide the necessary corrections, then the analyzer may be in need of maintenance (i.e. faulty PMT tube or flash lamp).

   a. Troubleshoot for possible electronic malfunctions (refer to Section F.4, *Troubleshooting*).

   b. Recalibrate after maintenance is performed, repeating Steps 1 to 13 of Section F.6.3.

APPENDIX G: OZONE ANALYZER

STATE OF IDAHO

DEPARTMENT OF ENVIRONMENTAL QUALITY

AIR MONITORING QUALITY ASSURANCE

STANDARD OPERATING PROCEDURES

FOR

ADVANCED POLLUTION INSTRUMENTATION, INC. (API)

MODEL 400 OZONE ANALYZER

APRIL 2001

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ADVANCED POLLUTION INSTRUMENTATION, INC. (API) MODEL 400 OZONE ANALYZER

FIGURES

TABLES

API 400 OZONE ANALYZER

TABLE OF ACRONYMS, UNITS, AND CHEMICAL NOMENCLATURE

AC	Alternating current
A/D	Analog-to-Digital
API	Advanced Pollution Instrumentation
Ccm	cubic centimeter per minute
CFR	Code of Federal Regulations
CPU	Central processing unit
D/A	Digitial-to-Analog
DAC	Digital-to-Analog converter
DC	Direct Current
DCPS	Direct Current Power Supply
DVM	Digital voltmeter
IZS	Internal zero/span
Lpm	liters per minute
MV	millivolts
O_3	Ozone
Ppb	parts per billion
Ppm	parts per million
SCCM	Standard cubic centimeters per minute
TFE	Tetrafluoroethylene
UV	ultraviolet

G.1. GENERAL INFORMATION

G.1.1 Theory

The API 400 ozone analyzer measures the amount of ultraviolet radiation absorbed by molecular ozone in a sample of ambient air. The quantity of light absorbed is proportional to the concentration of ozone in the air sample. A detailed discussion of the scientific basis of the analyzer measurement principle is contained in the manufacturer's instruction manual.

This document supplements the manufacturer's manual with instructions for servicing and troubleshooting the analyzer.

G.1.2 Analytical Cycle

A sample is drawn into the analyzer through a 5 micron Tetrafluoroethylene (TFE) particulate filter element by a vacuum pump capable of pulling 800 cubic centimeters per minute (ccm) across a critical flow orifice. Every eight seconds the API 400 completes a measurement cycle. This is accomplished through the use of a three-way solenoid valve.

The solenoid is de-energized and sample air is drawn through the ozone selective zero filter (scrubber) into the absorption chamber. After the absorption chamber is purged with scrubbed air for two seconds, a reference measurement of the ozone-free sample is made (I_o) for two seconds. The solenoid is then energized allowing the sample air to bypass the scrubber and purge the absorption chamber for two seconds. During the remaining two seconds, the average light intensity, I, is measured. Measurement of I_o every eight seconds minimizes instrument drift. Lamp aging and dirt accumulation contribute to instrument drift resulting in changing lamp intensity. The intensity of light is converted into a voltage by the detector/pre-amp module. The voltage is then converted into a number by a voltage-to-frequency (V/F) converter capable of 80,000-count resolution. This digitized signal, along with the other variables, is used by the central processing unit (CPU) to compute the concentration using the following formula:

$$C_{O_3} = \frac{10^9}{\alpha * l} * \frac{T}{273^\circ K} * \frac{29.92 inHg}{P} * \ln\left(\frac{I}{I_0}\right)$$

Where:

I = Intensity of light passed through the sample
I_o = Intensity of light passing through ozone-free sample
∀ = Absorption coefficient
l = Path length
C_{03} = Concentration of ozone in parts per billion
T = Sample temperature in degrees Kelvin
P = Pressure in inches of mercury

G.1.3 Precautions

1. Do not look directly at the ultraviolet (UV) lamp since UV light could cause eye damage. Always use UV filtering glasses or view through glass.

2. Always remove the Alternating Current (AC) power cord from the instrument before attempting to remove or replace any parts. Hazardous voltages are present on the power supply module. When working on this analyzer use normal high voltage precautions.

3. Use a third wire ground on this analyzer.

4. Clean the sample cell carefully. Do not cause the tube to bind against the metal housings. The glass tube may break and cause serious injury.

G.2 ROUTINE SERVICE CHECKS

G.2.1 General Information

Routinely perform the service checks discussed below based on the attached schedule (Table G.2.1) and using the procedures documented in this section. In certain environments (e.g., very dusty environments or those with elevated pollutant levels) some maintenance procedures may need to be performed more frequently, but all checks should be performed at least at the prescribed intervals. Complete the Monthly Quality Control Maintenance Check Sheet (Figure G.2.1) weekly and submit it monthly to your supervisor.

G.2.2 Daily Checks

Check the sample flow rate through the analyzer. Depress the TEST button on the front panel display to view the sample flow rate. The sample flow through the analyzer should be approximately 800 ccm; a variation of up to ±10% is considered acceptable. Verify that the solenoid valve is cycling.

G.2.3 Weekly Checks

Record the following initial readings on the Monthly Quality Control Maintenance Check Sheet:

1. TIME - Depress the TEST button on the front panel display to view the current time of day. The time is displayed as HH:MM:SS.

2. O_3 MEAS (ozone measurement) - Depress the TEST button on the front panel display to view the O_3 MEAS. If the value falls outside this range, check and adjust the source lamp and UV detector as described in Section 10.6.6 of the instrument manual. This shows the most recent detector reading taken in the measure mode. The output is in millivolts (mV) with acceptable values ranging between 2500 - 4700 mV.

3. O_3 REF (ozone reference) - Depress the TEST button on the front panel display to view the O_3 REF. If the value falls outside this range, check and adjust the source lamp and UV detector as described in Section 10.6.6 of the instrument manual. This shows the most recent detector reading taken in the reference mode. The output is in millivolts, with acceptable values ranging between 2500 - 4700 mV.

4. PRES (pressure) - Depress the TEST button on the front panel display to view the PRES. If the value falls outside this range, check for pneumatic system problems as described in Section 10.6.1 of the instrument manual. Also check for problems with the pressure transducer as described in Section 10.6.5 of the instrument manual. This shows the absolute pressure of the sample gas in the absorption cell. The output is in inches of mercury (Hg) with acceptable values ranging from 0 to 1.0 inches Hg below ambient pressure.

5. SAMPLE FL (sample flow rate) - Depress the TEST button on the front panel display to view the sample flow rate. The sample flow rate through the analyzer should be approximately 800 ccm; variations of up to ±10% are considered acceptable. If the value falls outside this range check the pneumatic system for problems as described in Section 10.6.1 of the instrument manual. Also check the flow meter for problems as described in Section 10.6.5 of the instrument manual. This shows the sample flow rate through the analyzer.

Table G.2.1
API Model 400 Ozone Analyzer Service Schedule

	Daily*	Weekly	Monthly	Quarterly	Semi-Annually
Check Sample Flow	X				
Check Solenoid Cycling	X				
Record Various TEST Readings		X			
Perform Leak Check		X			
Perform Quality Control Check		X	X		
Submit Monthly Quality Control Check Sheet			X		
Replace Sample Particulate Filter		X**			
Check Solenoid for Leaks				X	
Perform Multi-Point Calibration					X
Calibrate Ozone Analyzer					X
Replace and Calibrate Ozone Scrubber					X
Clean Critical Flow Orifice and Clean/Replace Orifice Filter					X
Replace Ultra Violet Lamps, as Required					
Replace Solenoid, as Required					
Clean Optics, as Required					

* Or each day the operator services the analyzer.
** Or when required

MONTHLY QUALITY MAINTENANCE CHECK SHEET
API MODEL 400 OZONE SAMPLER

Location: ______________________ Month/Year: ______________________
Station Number: ______________________ Technician: ______________________
Property Number: ______________________ Agency: ______________________

Test Parameters		Readings			
	DATE:				
TIME	Current time of day (HH:MM:SS)				
O_3 MEAS	Current V/F conv mV, measure channel				
O_3 REF	Current V/F conv mV, reference channel				
PRES	Absolute Pressure – inHg				
SAMPLE FL	Sample flow through Analyzer (ccm)				
SAMPLE TEMP	Temperature of the sample				
ANA LMP TMP	Analyzer Lamp Housing Temp. (°C)				
BOX TEMP	Internal Box Temp. (°C)				
DCPS	DC Power Supply (Mv)				

OPERATOR INSTRUCTIONS:

a. Daily checks: Review data and strip charts.

b. Weekly Checks: Record test parameters.

Change inline particulate filter: Date:______/______/______/______/

c. As Required: Clean optical chamber and adjust photo lamp when O_3 ref < 2500 mV

d. Semi-Annual: Calibrate analyzer. Date last calibrated:________________________.

Date	Comments or Maintenance Performed:

Reviewed by: Date:

Figure G.2.1 Monthly Quality Maintenance Check Sheet

6. SAMPLE TEMP (sample temperature) - Depress the TEST button on the front panel display to view the SAMPLE TEMP. If the value falls outside this range, refer to Section 10.6.2 of the instrument manual. This is the temperature of the sample gas in the absorption cell. The output is in degrees Celsius (°C), with acceptable values ranging from 1° - 10 °C above ambient temperature.

7. ANA LMP TEMP (source lamp temperature) – Depress the TEST button on the front panel display to view the ANA LMP TEMP. If the value does not fall within the range of 52 ±2 °C, refer to Section 10.6.2 of the instrument manual for corrective action. This shows the temperature of the source lamp.

8. BOX TEMP – Depress the TEST button on the front panel display to view the BOX TEMP. If the value falls outside the range from 1° - 5 °C above ambient temperature, refer to Section 10.6.2 of the instrument manual. This is the temperature inside the analyzer chassis. The output is in degrees Celsius.

9. DCPS (Direct Current power supply) – Depress the TEST button on the front panel display to view the DCPS. If the value falls outside the range from 2250 - 2750 mV, refer to Section 10.6.4 of the instrument manual. This is the Direct Current (DC) power supply reference voltage, which is a composite of all voltages provided by the DC power supply.

Check for leaks by depressing the TEST button on the front panel display to view the sample flow rate. The sample flow through the analyzer should be approximately 800 ccm and variations of up to ±10% are considered acceptable. The flow should drop to zero when the analyzer's sample inlet is blocked. Otherwise, there is an air leak in the instrument. Procedures for leak checking are given in Section 1.2.3.

Replace the in-line Teflon® sample particulate filter at least weekly. Note the filter cleanliness and, if necessary, increase the replacement frequency. Even change the filter if a slight particulate coating or discoloration is visible. Note any unusual discoloration on the check sheet.

G.2.4 Monthly Checks

Record data weekly on the Monthly Quality Control Maintenance Check Sheet. –Each month, after completing the final week’s checks, give the check sheet to your supervisor.

G.2.5 Quarterly Checks

Using the procedure in Section G.3.4, check the solenoid valve for leaks. Record the test date on the Monthly Quality Control Check Sheet. If the solenoid valve leaks, contact your supervisor to arrange for an “as-is” calibration prior to solenoid valve replacement.

G.2.6 Semi-Annual Checks

1. Ozone Scrubber – Replace the ozone scrubber at least every six months of operation. Do not replace ozone scrubbers without an accompanying calibration. The guidelines for ozone scrubber replacement are given in Section G.5.2. Record the date that the scrubber was replaced on the Monthly Quality Control Check Sheet.

2. Multi-point Calibration - The ozone analyzer must be calibrated at least once every six months of operation, upon relocation, and after major repairs. One month prior to the ozone analyzer recalibration due date, contact your supervisor to arrange for a multi-point calibration. Record the date of the most recent calibration on the Monthly Quality Control Check Sheet.

3. Critical Flow Orifice - Clean the critical flow orifice and either clean or replace the orifice filter. A dirty orifice filter can cause a low flow condition in the Advanced Pollution Instrumentation, Inc. (API) Model 400. The critical orifice is located on the inlet side of the sample pump at the elbow fitting. The orifice can be disassembled and cleaned with low pressure zero air, and the orifice filter cleaned with denatured alcohol. Refer to Figure G.2.2 for re-assembly instructions

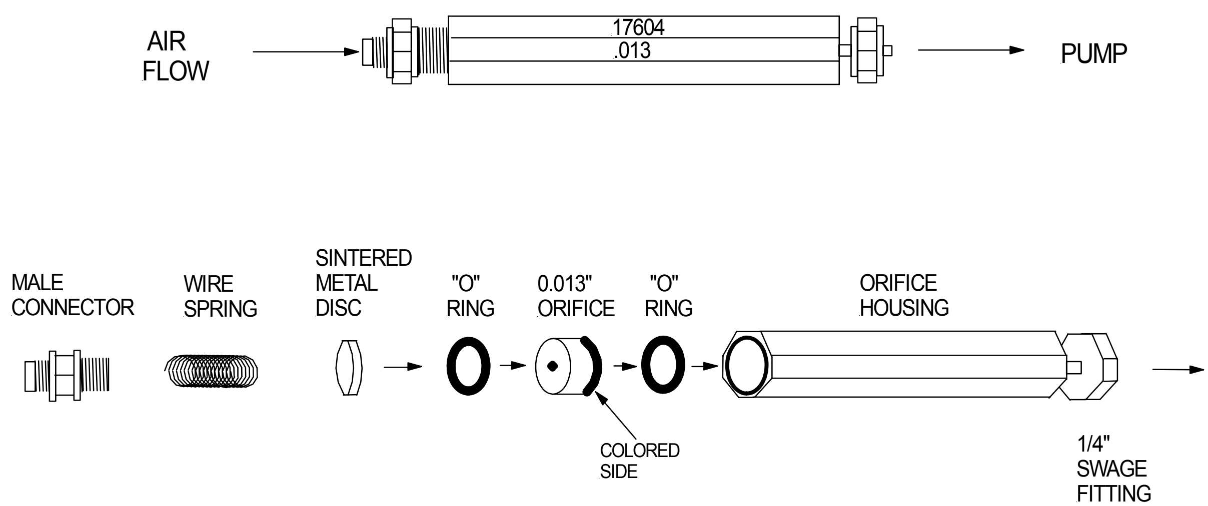

Figure G.2.2 Critical Flow Orifice and Filter

G.3 DETAILED MAINTENANCE AND ALIGNMENT PROCEDURES

The following adjustments are for an analyzer operating on a full-scale range of 500 parts per billion (ppb) and a recorder with full-scale response of 1 volt. The API Model 400 has several ranges that are user selectable. If an alternate range of operation is selected, appropriate adjustments must be applied.

G.3.1 A/D – D/A Calibration

Analog-to-Digital (A/D) and Digital-to-Analog (D/A) converters may periodically need calibration. This procedure should only be performed when a major sub-assembly is exchanged or when the analog output voltage range is changed.

1. Press SETUP-MORE-DIAG.

2. Enter the diagnostic password and press NEXT until D/A CALIBRATION appears in the display; press ENTR.

3. Press “ADC” to perform the A/D calibration.

4. The display on the API Model 400 will read “ADJUST ZERO: A/D=xx.x MV.” Put the probe of a digital voltmeter (DVM) between TP3 (AGND) and TP9 (DAC #0) located on the top of the Voltage/Frequency (V/F) card (see Drawing 00514, Appendix E in the instrument manual).

5. The value displayed by the DVM should be close (±20 mV) to the value on the Model 400 display. If the value isn’t close then the V/F card has probably been configured improperly.

6. Adjust the zero pot (R27) on the V/F card until the value on the API Model 400 display matches the value on the voltmeter to within ±2 mV. *Note that when adjusting R27, the value on the API Model 400 display will change, but the value on the voltmeter will remain constant.*

7. Press ENTR.

8. The API Model 400 display will now read “ADJUST GAIN: A/D=xx.x MV.”

9. Adjust the span pot (R31) on the V/F card until the value on the API Model 400 display matches the value on the DVM to within ±2 mV.

10. Press ENTR.

11. The ADC is now calibrated and the API Model 400 will auto-calibrate all of the Digital-to-Analog Converters (DAC).

G.3.2 Optics

Dirt, smoke, and filmy material drawn in with the ambient air sample will cloud the optics of the analyzer. Proper procedures for cleaning the optics (sample cell) are given in the manufacturer's instruction manual in Section 11.4.

Note: Care must be exercised when cleaning the sample cell. Do not cause the glass tube to bind against the metal housing because the tube may break. Clean the tube with soapy water, rinse it with isopropyl alcohol then de-ionized water, and let it air dry.

G.3.3 Ultraviolet Lamp Power Supply Adjustment

Use the following procedure to adjust the drive power of the Ultraviolet (UV) lamp power supply:

1. Remove the cover of the lamp power supply. Attach a DVM across TP7 and TP14, and adjust the pot (RV1) until the DVM reads 20 volts ± 1 volt.

2. Adjust the position of the source lamp. On the front panel of the instrument, press the TEST button until "O_3 REF" is displayed.

3. Loosen the lamp retaining screw and rotate the lamp until the O_3 REF reading on the display is 4500 mV ± 320 mV. (*Note: use only ¼ revolution adjustments and wait at least six seconds for the O_3 REF display to update*.) Re-tighten the lamp retaining screw.

4. Adjust the UV detector pre-amp gain by removing the access cap on the detector cover at the front end of the optical bench and adjusting the pot (R7) until the O_3 REF reading on the display is 4500 mV ± 50 mV.

5. If it is not possible to adjust the O_3 REF display to 4500 mV, increase the UV lamp power by adjusting the lamp power supply again as described in step 1. (*Note: do not allow the voltage across TP7 and TP14 to exceed 21 volts*.) If it is still not possible to achieve an acceptable O_3 REF value, it is possible that the lamp has deteriorated beyond its useful range and should be replaced.

6. Recalibrate the automatic detector dark current compensation by performing the following steps in order:

   a) Press SETUP

   b) Press MORE

   c) Press O_3

   d) Press DARK

   e) Press CAL

For more information on the dark current adjustment procedure, refer to the manufacturer's instruction manual.

G.3.4 Leak Check Procedure

Depress the TEST button on the front panel display to view the sample flow rate. The sample flow through the analyzer should be approximately 800 ccm; variations of up to ±10% are considered acceptable. The flow should drop to zero when the analyzer's sample inlet (0.25-inch fitting) is blocked. Otherwise, there is an air leak in the instrument.

Section 11.3 in the instrument instruction manual provides detailed procedures for leak checking the API Model 400. It should be noted that if a leak is detected by the above method, the pressure method described in the instrument instruction manual is the preferred means of determining the location of the leak. Care must be exercised to ensure that no leak checking solution enters the sample cell, especially when checking the O-ring seals at each end of the glass sample cell of the optical bench. The maximum pressure for the leak check is 15 pound per square inch.

OZONE ANALYZER CALIBRATION DATA SHEET

SITE NAME ____________________________ CALIBRATION AS IS _____ FINAL _____
SITE NUMBER _________________________ DATE __________ LOG NO ____________
SITE TEMP (_ C) _______________________ SITE ELEVATION _____________ (FEET)
BAROMETRIC PRESSURE (mmHg) _______ ALT. CORRECTION FACTOR __________

<u>TRANSFER STANDARD</u>
MAKE & MODEL ____________________________
PROPERTY NO. _____________________________
SAMPLE FREQ.(DISPLAY) ___________________
CONTROL FREQ. (DISPLAY) _________________
AIR FLOW (DISP) _____ SETTING _____________
SPAN DIAL SETTING _____ DISP _____________
TRUE O3 CORRECTION FACTOR _____________

<u>ANALYZER BEING CALIBRATED</u>
MAKE & MODEL ________ PROPERTY # ________
AS IS SLOPE _____ OFFSET _____ RANGE _______
FINAL SLOPE _____ OFFSET _____ O3 MEAS ____
O3 REF _____ SAMPLE TEMP _____ LAMP T _____
BOX T _____ DCPS _____ PRESSURE ____________
AIR FLOW SETTING ______ DISPLAY ___________
FLOW MEASUREMENT DEVICE _______________

Pre-0	1^{ST} Pt.	2^{nd} Pt.	3^{rd} Pt.	4^{th} Pt.	Post-0		Pre-0	1^{ST} Pt.	2^{nd} Pt.	3^{rd} Pt.	4^{th} Pt.	Post-0
						1						
						2						
						3						
						4						
						5						
						6						
						7						
						8						
						9						
						10						
						Avg Disp						
						Chart						
						DAS						
						Corrected Avg						

Corrected Avg = [Avg Reading □ ((Pre-0 + Post-0) / 2)] x TOCF

Calibrated by: ________________ Checked by: _________________

Figure G.3.1 Ozone Analyzer Calibration Data Sheet

G.4 CALIBRATION PROCEDURES

An API Model 401 ozone analyzer/calibrator (transfer standard), or an equivalent, standardized against a primary standard laboratory UV photometer is used in calibrations. The response of the analyzer being calibrated is compared to the response of the transfer standard.

G.4.1 Apparatus

1. API certified ozone analyzer/calibrator.
2. One-quarter inch Teflon® tubing for airflow connections.
3. Charcoal zero air scrubber (Gelman Model No. 12011, or equivalent).
4. Calibrated laminar flow device for measuring air flow (Vol-o-flo, or equivalent).
5. Calibration Data Sheet (Figures G.3.1) and Calibration Report Form (Figures G.4.1).
6. Spare scrubber.
7. Calibration line if using the calibrator for the ozone source.

G.4.2 Ozone Scrubber Replacement

The policy concerning ozone scrubber replacement is as follows:

1. Replace ozone scrubbers only at the time of calibration and only after performing an "as-is" calibration. After replacing an ozone scrubber, perform a multi-point calibration.
2. No field scrubber replacement is required for seasonal ozone monitoring. At the end of the ozone season, return the analyzer to the Air Quality Monitoring support facility for overhaul. The overhaul includes scrubber replacement and a multi-point calibration check.
3. For analyzers operating continuously for a full year, replace the ozone scrubber during the pre-ozone season calibration. Although recommended, it is not necessary to replace the ozone scrubber during the post-ozone season calibration, but do replace it semi-annually.

G.4.3 Calibration at Altitude

Calibrating the API Model 400 analyzer for altitudes greater than or equal to 1,000 feet above mean sea level requires no special adjustments because the analyzer compensates for changes in temperature and pressure. At the time of calibration, verify the operation of the transducers in the analyzer by recording the values of sample temperature and pressure from the analyzer and from a certified transfer standard at ambient conditions. The API Model 401ozone analyzer/calibrator requires no altitude correction if pressure and temperature compensation are turned on, therefore using a factor of 1.000 at all altitudes. Calibrate the analyzer as described in Section G.4.4.

Note: The transducers in the API Model 400 measure the temperature and pressure of the gas in the photometer cell. These values may not match ambient conditions. The pressure should display 29 –30 inches of Hg at sea level and should closely match the ambient pressure. If it doesn't, an obstruction may be present between the photometer cell and the output line. The sample temperature should be within ±10 °C of the ambient temperature. If it isn't, replace the temperature sensor.

G.4.4 "As-Is" Calibration

Other than routine checks, analyzer repairs or adjustments should not be made prior to the "as-is" calibration. The ozone scrubber and/or solenoid valve should not be replaced without first performing an "as-is" calibration. Perform the "as-is" calibration following these steps:

1. Assemble the equipment and allow zero air to flow through the system.

2. While sampling zero air, allow both the transfer standard and the analyzer being calibrated to warm up for at least one hour. The covers of both instruments should be on during the calibration, as the calibration is dependent upon the internal temperature of the analyzer. The transfer standard readings should be stable, showing no upward or downward trend when the analyzer has reached operating temperature.

3. Record the analyzer identification numbers, analyzer settings, "as-is" slope and offset, and any other pertinent information on the Ozone Analyzer Calibration Data Sheet (Figure G.3.1). Verify the "as-is" slope and offset are the same as at the end of the previous calibration. If not, investigate when and why the analyzer was reset before making adjustments.

   Obtain the instrument internal slope and offset readings from the API Model 400 front display following these steps:

   a. Press SETUP

   b. Press MISC

   c. Press O_3

   d. Press SLOPE

   e. Press EXIT

   f. Press OFFSET

   g. Press EXIT four times to get back to main menu

4. Verify that the output flow of the API Model 400 transfer standard is set to 5 liters per minute (lpm) using the calibrated laminar flow device. Measure and record the "as-is" sample airflow rate of the analyzer being calibrated. Connect an 18-inch Teflon® line (0.25-inch diameter) to the vent port of the transfer standard and measure the vent flow. The vent flow should be greater than 0.5 lpm.

5. While the analyzer and transfer standard are sampling zero air, record 10 consecutive digital display values from the analyzer being calibrated in the left most column labeled "Pre-0" on the Calibration Data Sheet. Calculate the average of the 10 numbers and record the value on the Calibration Data Sheet in the respective blocks. Record the average strip chart (and/or other data acquisition system) reading in the space provided.

6. Set the lamp intensity control (or thumb-wheel setting) of the transfer standard to produce an ozone concentration of approximately 400 ppb O_3 as read by the transfer standard.

7. Record 10 consecutive digital values in the columns labeled "1st Pt." for each analyzer. Calculate the average of the 10 numbers and record the value on the Calibration Data Sheet in the appropriate blocks. Record the average strip chart recorder (and/or other data acquisition system device) reading in the appropriate space.

8. After adjusting the ozone generator output to approximately 300, 200, and 100 ppb, record data for the "2nd Pt.," "3rd Pt.," and "4th Pt.," respectively. Calculate and record the average readings. (Use approximately 400 ppb and 90 ppb as two of the points if also calibrating the output of the station calibrator for daily spans and precision checks.)

9. Repeat step 5 and record the value in the volumes marked "Post-zero." Average the "Pre-0" and "Post-0" readings and use this value as the zero correction.

10. Calculate corrected averages for the transfer standard analyzer using the formula:

$$Corrected\_Ave_{(xfer-std)} = \left(\mathrm{Re}ading_{Ave.} - Zero_{Correction}\right) * \left(CF_{True\_O_3}\right) * \left(CF_{Altitude}\right)$$

Where: CF = Correction Factor

11. Calculate the sum of the corrected averages for the transfer standard by adding the corrected averages for points 1, 2, 3, and 4.

12. Calculate the corrected averages of the analyzer being calibrated using the formula:

$$Corrected\_Ave = Ave\_\mathrm{Re}ading - Zero\_Correction$$

These values, in parts per billion, should correspond to the analyzer's digital display. If not, check the calibration of the recording device before making adjustments to the analyzer.

Note: If a strip chart recorder or data acquisition system is used for primary data recording, then that data should be used in the calculations instead of the display readings.

13. Calculate the sum of corrected averages for the analyzer being calibrated by adding the corrected averages for points 1, 2, 3, and 4.

14. Calculate the overall average percent difference from true ozone using the following equation:

$$Ave\_\%\_Deviation\_from\_True\_O_3 = \left(\frac{S2 - S1}{S1}\right) * 100\%$$

15. Using a best fit linear regression, calculate the slope (m) and intercept (b) equation of the calibration line:

Where: x = true concentration, in

y = analyzer response, in parts per million

16. Calculate the percent change from the previous calibration:

$$\Delta\% = \left(\frac{New\_Slope - Old\_Slope}{Old\_Slope}\right) * 100\%$$

17. Record the requested information on the front of the Calibration Report (Figure G.4.1).

G.4.5 Final Calibration

If the percent difference reported in G.4.4, step 14 is greater than ±5%, or if the ozone scrubber is replaced (see Section G.4.2), the analyzer must undergo a final calibration.

Perform the final calibration as follows:

1. Challenge the API Model 400 with zero air until the reading stabilizes (not more than ±2% of range over a five-minute time period).

   Note: If the analyzer fails to stabilize on zero air at an output between ±25 ppb, it will be impossible to enter zero and it will be necessary to refer to the troubleshooting section of the manufacturer's instruction manual.

2. Zero the API Model 400 by performing the following steps in order:

   a. Press CALM

   b. Key in the calibration password

   c. Press ENTER

   d. Press ZERO

   e. Press ENTER

   f. Press EXIT two times

The API Model 400 is now zeroed, but the blinking cal light and words "HOLD OFF" indicate that data are not being sent out. This status will last approximately five minutes.

3. Record 10 display updates on zero air in the “pre-0” column on the Calibration Data Sheet.

4. Challenge the API Model 400 with a span level of ozone. This level should generally be about 80% of the analyzer full scale, or about 400 ppb on the 500 ppb scale. Allow the span level to stabilize for sufficient time to determine that the API reading is within ±10% of the true value.

   Note: If the analyzer fails to stabilize at a span reading within ±10% of the correct span, it will not be possible to span the instrument. Consult the troubleshooting section of the manufacturer's instruction manual if this happens.

5. When the span level is stable, set the span on the API Model 400 by performing the following steps in order:

   a) Press SETUP

   b) Press IZSC

   c) Key in the calibration password

d) Press ENTER

e) Press SPAN

f) Enter the ozone concentration in parts per billion

g) Press ENTER

h) Press EXIT

i) Press EXIT

j) Press CALM

k) Key in the calibration password

l) Press ENTER

m) Press SPAN

n) Press ENTER

o) Press EXIT

6. Obtain the instrument internal slope and offset from the API Model 400 front display following these steps:

   a) Press SETUP

   b) Press MISC

   c) Press O_3

   d) Press SLOPE

   e) Press EXIT

   f) Press OFFSET

   g) Press EXIT four times

7. Record the (final) slope and offset on the Ozone Analyzer Calibration Data Sheet (Figure G.3.1).

8. Record on the Calibration Data Sheet 10 display updates at this span level for high point.

9. Return to G.4.4 ("As-Is" Calibration), step 8, to complete the remaining steps of the final calibration.

   Note: If the analyzer cannot be properly calibrated, refer to the API Model 400 instruction manual for assistance in troubleshooting and repairing the analyzer.

API MODEL 400 OZONE ANALYZER
CALIBRATION REPORT

TO: AIR QUALITY MONITORING LOG NUMBER:
FROM: INSTRUMENT TECH CALIBRATION
DATE:

IDENTIFICATION

Instrument: API	Site Name:
Model Number: 400	Site Number:
Property Number:	Site Location:
Serial Number:	
Previous Cal Log Number:	Instrument Property of:
Elevation:	Barometric Pressure: □ Hg

CALIBRATION STANDARDS

STANDARD	I.D. Number	Certification Date	Certified Value
API Model 401			

CALIBRATION RESULTS

Component		OZONE		
Instrument Range, ppm		0 – 1		
Initial Instrument Slope				
Initial Instrument Offset				
Air Flow Rate, sccm				
Air Flow Indication				
Best Fit Linear Regression (X = True, Y =)	Slope			
	Intercept			
□AS IS□ Deviation from True		%		
□Final□ Deviation from True		%		
Change From Previous Calibration, % (date)		%		
Final Instrument Slope				
Final Instrument Offset				

Comments:

Calibrated by:______________ Checked by:_________________

Figure G.4.1 Calibration Report

G.5 INTERNAL ZERO/SPAN PROCEDURES

The API Model 400 is available with an internal zero/span (IZS) option. The IZS option includes a sample/cal valve, a zero air scrubber, and a temperature controlled ozone generator. The concentration of ozone can be set through the front panel controls or the RS-232 port. The ozone generator lamp intensity can be monitored and fed back via the instruments CPU for very accurate and stable ozone concentrations using the feedback detector option.

In the zero mode, ambient air is drawn through the charcoal scrubber and filter, the un-energized ozone generator, and the energized sample/cal valve into the analyzer. In the span and precision mode, the ozone generator is energized and the resulting span and precision gas is drawn through the energized sample/cal valve into the analyzer.

G.5.1 Internal Zero/Span Ozone Generator Setup

The API Model 400 with the IZS option offers the capability to check one zero and two span points (or one precision point and one span point) automatically on a timed basis, or through remote RS-232 operation.

It is recommended that the IZS option be used to provide a nightly zero, precision, and span check of the API Model 400. While 40 CFR Part 58, Appendix A only requires the submission of biweekly precision points for each criteria pollutant monitor, these nightly checks provide valuable data on the operational integrity of both the optical bench and the IZS generator. By performing nightly zero, precision, and span checks, instrument response can be tracked and operational problems quickly identified and corrected.

Nightly zero, precision, and span checks should be programmed to begin at 02:00 daily with a 15-minute duration for each step. While this eliminates approximately one full hour of data, the time of day selected is best suited so as not to interrupt daily maximum hourly averages. Additionally, the benefits provided by a nightly instrument check to evaluate analyzer response trends outweigh the impact on the overall percent data capture of the instrument. Program the API Model 400 AZS unit to perform the nightly checks following these steps:

1. Set the IZS span concentration to 400 ppb by performing the following:

   a. Press CALS

   b. Press CONC

   c. Press O_3GEN

   d. Enter a value of 400 ppb

   e. Press ENTER

2. Set the IZS precision concentration to 90 ppb by performing the following:

   a. Press SETUP

   b. Press MORE

c. Press VARS

d. Enter the calibration password

e. Press NEXT until "O_3_GEN_LOW1" is displayed

f. Press EDIT to change the concentration to 90 ppb

g. Press ENTER

3. Use the SETUP – ACAL menu to program the first auto-sequence, called "SEQ1." Select the ZERO-LO-HI sequence mode, program the desired start date, program the start time to 02:00, select the delta day of 1, the delta time of 00:00, and finally a duration of 15 minutes. This will allow the API Model 400 IZS unit to perform a nightly zero, precision, and span check of the API Model 400. Each parameter is defined in the instrument instruction manual in Section 3.4. As a reference refer to the example below:

   MODE: ZERO-LO-HI

   STARTING DATE: Current date in MM/DD/YY format

   STARTING TIME: 02:00

   DELTA DAYS: 1

   DELTA TIME: 00:00

   DURATION: 15

4. The API Model 400 is now ready to perform nightly zero, precision, and span checks. It should be noted that the IZS unit must be calibrated as specified in Section 3.0.2 in the instruction manual before nightly checks are started and after performing the above-described setup.

G.5.2 Internal Zero/Span Ozone Generator Calibration

The IZS ozone generator must be calibrated against the analyzer by using the analytical section of the API Model 400 to determine the ozone generator's output. Calibrate the IZS ozone generator using the steps listed below.

Note: The API Model 400 must be calibrated from an external ozone source before performing the IZS ozone generator calibration.

To start the calibration process perform the following steps in order:

a. Press SETUP

b. Press MORE

c. Press DIAG

d. Key in the calibration password

e. Press ENTER

f. PRESS O_3 GEN CAL

The API Model 400 will measure the IZS reference signal and the ozone concentration at six different IZS lamp drive points: 400, 600, 800, 1000, 2000, and 5000 mV.

For each test point, the instrument waits 10 minutes for the API Model 400 to stabilize, then takes two readings and stores them.

During the calibration process, the instrument displays percent of completion so that the progress of the calibration can be monitored. Full calibration will take approximately one hour.

The calibration can be aborted by pressing EXIT. If the calibration is aborted in the first 10 minutes no changes will be made to the previously stored values. However, if aborted after 10 minutes the instrument will not restore values and the calibration table will remain modified.

Once the above steps are completed, the internal ozone generator is ready for use.

APPENDIX H: METEOROLOGICAL DATA COLLECTION SYSTEMS

STATE OF IDAHO

DEPARTMENT OF ENVIRONMENTAL QUALITY

AIR MONITORING QUALITY ASSURANCE

STANDARD OPERATING PROCEDURES

FOR

AIR QUALITY MONITORING

METEOROLOGICAL DATA COLLECTION SYSTEMS

MONITORING, MODELING, AND EMISSIONS INVENTORY

MARCH 2003

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Radiance Research Model M903 Integrating Nephelometer

TABLES

Radiance Research Model M903 Integrating Nephelometer

Acronyms, Units, And Chemical Nomenclature

AQS	Air Quality System
DC	Direct Current
DEQ	Department of Environmental Quality
EPA	Environmental Protection Agency
Lpm	Liters per minute
Mph	Miles per hour
m/s	Meters per second
Nm	Nanometer (10^{-9} meter)
Rpm	Revolutions per minute

Appendix H: Meteorological Data Collection System

Analytes: Wind Speed, Wind Direction, Temperature, Temperature Differential, Relative Humidity, Solar Radiation, Pressure

Procedures: Wind Speed: Helicoid Propeller/AC Sine Wave
Wind Direction: Potentiometer
Temperature: Linear Temperature Probe
Temperature Differential: Vertical Probe Separation
Relative Humidity: Capacitive Relative Humidity Sensor
Solar Radiation: Silicon Photovoltaic Detector
Pressure: Silicon Capacitive Pressure Sensor

Ranges: See Table H.3.1 for Ranges of All Meteorological Parameters

H.1 INTRODUCTION

The collection of valid meteorological data is an important part of an air quality regulatory program. The use of such information is an invaluable tool when attempting to characterize the transport and dispersion of air pollutants within a region. As such, it is vital that the data be as spatially and temporally representative of the area as possible. This document has been written to provide general guidance to experienced personnel on maintaining, ensuring, and establishing standards for the accuracy and quality of data collected from meteorological sites throughout Idaho. If the guidelines set forth in this procedure for operating and auditing a meteorological system are followed, meteorological data that meet prevention of significant deterioration quality standards will be collected. This data will meet or exceed the minimum requirements for the data quality necessary to submit into the Air Quality System (AQS) and to use for air quality modeling.

H.2 DATA REQUIREMENTS

In order to have an acceptable meteorological database, 12 consecutive months of valid measurements must be taken. Each monthly data set must be 90% complete. Substitutions for missing information are allowed, but they are not to exceed 10% of the total hours represented. At a minimum, the meteorological database should include hourly averages of pressure, temperature (measured at one or more levels), relative humidity, and wind speed and direction.

Although hourly averages may be calculated from samples taken over the entire hour, shorter time intervals are often used to provide these values. Not only do shorter time periods reduce the potential for errors in the calculations, but they also provide for a more complete picture of the actual meteorological conditions present when the data were collected. This, in turn, can help when analyzing transitional periods in the measured variables.

The accuracy with which the calculated averages represent the true value is dependent upon the number of samples taken. It has been shown that a sampling error of 5 to 10% may be obtained when estimating the mean from a set of at least 60 samples and when calculating the standard deviation from a minimum of 360 evenly spaced data points. For this reason, the number of samples recommended for an accurate determination of standard deviation (sigma theta [σ_θ]) is equal to or greater than 360. If an hourly standard deviation is to be calculated, then the data must be sampled at least once every 10 seconds. If the collected information is to be combined into 15-minute averages, then the data must be sampled at least once every 2.5 seconds to provide the necessary 360 values.

Although the on-site data logger can reduce the collected measurements into 15-minute and hourly averages, it is very important to be careful when choosing a scanning interval. The scanning interval must be short enough to yield the required number of values during the averaging period to attain the specified accuracy, yet long enough to successfully query all of the instruments, store the data, and perform the necessary calculations. Additional data logger information may be found in the instrument's supporting documents. Methods for processing the collected data may be found in section 6 of the U.S. Environmental Protection Agency (EPA) document, *On-site Meteorological Program Guidance for Regulatory Modeling Applications*.

H.3 CHOICE OF INSTRUMENTATION

There are numerous factors to consider when determining what instruments to install at a site. These factors include, but are not limited to, the potential uses for the data and the overall project requirements (i.e., the individual accuracy and frequency demands that need to be met). The durability of the individual sensors should also be factored into the decision-making process.

Careful attention must also be paid to the internal response characteristics of the instruments chosen. These play an important role in not only helping to maintain the accuracy of the collected information but also in helping to ensure that the data will adequately satisfy its intended application. For example, in order to accurately determine sigma theta (σ_θ) of the wind direction for use in deriving the atmospheric stability category, the wind sensors must possess certain minimum response characteristics. The most important of these is the damping ratio, which must be between 0.4 and 0.7. A list of the recommended criteria to be met by each sensor is provided in Table H.3.1.

Table H.3.1

Specifications for Meteorological Instrumentation

Parameter	Criteria
TEMPERATURE	
Accuracy	± 0.5 °C
Resolution	0.1 °C
Range	-40 °C ≤ T ≤ 60 °C
Probe Error*	± 1.0 °C
Time Constant	≤ 1 minute
DELTA TEMPERATURE	
Relative Accuracy	± 0.1 °C
Resolution	0.0 2°C
Range (for _T)	- 5 °C ≤ T ≤ 15 °C
Errors in _T should not exceed	0.003 °Cm^{-1}
Time Constant	≤ 1 minute
WIND SPEED	
Accuracy**	± (0.2 ms^{-1} + 5% of the observed)
Resolution	0.1 ms^{-1}
Range	0.0 ms^{-1} ≤ ws ≤ 50 ms^{-1}
Starting Threshold	≤ 0.5 ms^{-1}
Distance Constant	≤ 5 m
WIND DIRECTION	
Accuracy	
Internal Sensor	± 3°
Alignment of Overall System	± 5°
Resolution	1°
Range	0° ≤ wd ≤ 360°
Starting Threshold	≤ 0.5 ms^{-1} @ 10°
Delay Distance	≤ 5 m
Overshoot	≤ 25%
Damping Ratio	0.4 - 0.7
RELATIVE HUMIDITY	
Accuracy	± 5%
Resolution	≤ 1%
Range	10% ≤ RH ≤ 90%
BAROMETRIC PRESSURE	
Accuracy	± 3.05 mb
Resolution	0.5 mb
Range ***(a function of elevation)	~Pavg ± 203.2 mb (± 20.32 kPa)
SOLAR RADIATION	
Accuracy	± 5% of the observed
Resolution	10 Wm^{-2}
Range	0 Wm^{-2} ≤ SR ≤ 1370 Wm^{-2}
Operating Range	-20°C - +40°C

*If fog formation or icing is believed to be a significant problem, then errors in the measured temperatures should not exceed 0.5 °C.

**At wind speeds greater than 5 ms^{-1}, the wind speed system should be accurate to within ±5% of the observed.

***May be necessary to buy different sensors for different elevations.

H.4 SITING/INSTALLATION

Since inadequate siting and improper exposure of the instruments may induce substantial errors in the data, both the location of a monitoring site and the physical position chosen for each of the individual sensors are important when designing a meteorological network. In general, the sensors should be placed over level, open terrain outside the influence of any external obstructions, both manmade and natural, that may effect the general airflow pattern near and around the measuring site. An understanding of the scope of the measurements needed is also essential in the design of any data collection network as it will help to ensure that local phenomena, regional phenomena, or both are fully resolved to meet all of the necessary data requirements.

Although proper siting of the measuring system is essential in ensuring the quality of the data collected, it may often be difficult to find a location that will meet all of the recommended criteria. As a result, it is the responsibility of both the field and auditing personnel to document and, if possible, evaluate the potential biasing effects of any site deficiencies upon the collected data. This will allow for a more accurate interpretation of the measurements at a later time. In general, special care should be taken to ensure that the measurements meet most of the data requirements of the project at hand and are not unduly biased by local terrain features or manmade obstructions. The following sections provide a summary of the siting specifications for each of the aforementioned meteorological variables.

H.4.1 Towers

Although meteorological equipment is often mounted on a tower, the tower itself may induce errors in the measurements due to a distortion of airflow around the sensors. As a result, it is important to ensure that the measurements taken are not unduly affected by turbulence in the wake of the tower. Open-latticed towers have been found to reduce wake effects and are preferred over closed ones. It is also important to make sure that the towers and booms chosen for use at the site are sturdy enough to withstand any vibrations that may be brought about by strong winds.

H.4.2 Wind Sensors

In rural and flat areas it is generally recommended that the wind sensor be located over level, open terrain at a height of 10 meters above the ground and at a distance of at least 10 times the height of any nearby obstruction. If this exposure is not easily obtainable, then the sensor should be placed at a height that will not be affected by nearby obstructions and is as representative of the wind at the 10 meter level as is reasonably possible. For elevated releases, or sources located in complex terrain, the wind speed should be measured at stack top, or at 100 meters, whichever is lower.

It is recommended that the wind sensors be mounted on booms at least two structure widths away from the nearest point on the tower and at a 90° angle to the predominant wind direction to help minimize the effects of turbulence induced eddies. A wind sensor installed on top of a tower should be located at least one tower diameter above the supporting structure. If the wind sensor is to be mounted on top of a building, it should be located high enough above the rooftop to avoid the wake affects caused by the distortion of airflow around the building. In general, the total depth of this area is estimated to be approximately 2.5 times the height of the building.

Follow the steps listed below when installing a wind sensor.

1) Check the wind sensor for physical damage before installation. The bearings should be examined for smooth, unimpeded movement and the cables should be free of any damage or wear.

2) Check the vane's balance by holding the sensor's base so that the vane surface is horizontal. The instrument should, in this position, experience a near neutral torque and should have the tendency to rotate.

3) Place the orientation ring on the mounting post. The sensor should be perfectly level when mounted to ensure proper operation. The orientation ring and mounting post band clamps should not be tightened until after the sensor has been aligned.

4) Orient the sensor to true and not magnetic north. You can do this using a compass that has been adjusted for the correct magnetic declination angle. Table H.4.1 contains a list of declination angles for assorted cities in Idaho. The values are specified in degrees east and need to be subtracted from 360 before the compass can be corrected.

Table H.4.1

Magnetic Declination Variation In The State Of Idaho

Place Name	Elevation (Ft.)	N. Latitude	W. Longitude	Declination (°E)
Coeur d'Alene	2,391	47° 43'	116° 35'	17.9°
Moscow	2,575	46° 44'	116° 57'	18.0°
Boise	2,842	43° 38'	116° 12'	16.3°
Pocatello	4,460	42° 54'	112° 30'	14.8°
Twin Falls	3,750	42° 33'	114° 29'	15.4°
Hyndman Peak	12,078	43° 38'	114° 04'	15.6°
Sandpoint	2,085	48° 17'	116° 34'	18.1°
Bonners Ferry	1,787	48° 41'	116° 19'	18.2°
Salmon	4,004	45° 11'	113° 54'	18.0°

Magnetic declination calculated with GEOMAG Software (Naval Oceanographic Office) using the WGS-84 Ellipsoid (World Geodetic System) and the WMM-95 (World Magnetic Model, 1995). Elevations are approximate.

5) Once the angle has been determined and the compass has been adjusted, turn the compass until its needle is pointing to zero. This is the direction of true north. All efforts should be made to align the sensor to within ±1° of true north.

6) Choose a minimum of three reference points to help align the wind sensor.

7) Using the compass, determine the direction of each of the points.

8) Record these directions and a detailed description of each point in a log book. Adequate documentation will allow for easier verification of the sensor's orientation and response at a later date.

9) Leave the mounting screws on the orientation collar loose so that the entire sensor/collar assembly can be easily rotated.

10) Sighting down the shaft centerline, line the nose of the sensor up with the various reference points.

11) While holding the instrument in position, reach in through the front of the main housing unit and slowly adjust the potentiometer thumb wheel until the correct measurement is obtained on the data logger display. The value should be within 5° of the correct reading.

12) Tighten the setscrew on the potentiometer coupling before attempting to replace the nose cone. Tighten the mounting post band clamp.

13) Engage the indexing pin located in the notch at the instrument's base before tightening the orientation ring band clamp.

H.4.3 Temperature Sensors

Ambient air temperature sensors should be installed 2 meters above an open, level, grassy area that is at least 9 meters in diameter. The ground should be covered with short grass, or bare ground in those areas where grass does not grow. It is important to ensure that the sensors are not mounted above or within the vicinity of concrete, asphalt, or any other material that may induce errors in the resulting temperature measurements. The instrument should be mounted on a boom whose minimum length is at least the diameter of the tower.

In order to obtain accurate readings, the measuring devices should be protected from thermal radiation caused by the sun, sky, ground, and any nearby structures. In addition, the temperature sensors should be placed at a distance of at least four times the height of any nearby obstructions and at least 30 meters away from any large paved stretch of land. The sensors should also be protected from the influence of any nearby industrial heat sources, rooftops, steep slopes, shaded regions, areas prone to the formation of snowdrifts, and low places characterized by standing water.

When estimating surface layer stability parameters, measurements of the temperature difference should be taken between 2 meters and 10 meters above the ground. When calculating Pasquill-Gifford stability categories, the lower sensor should be located between $20z_0$ to $100z_0$, where z_0 is the surface roughness length. Table H.4.2 contains a list of the recommended surface roughness lengths.

Table H.4.2

Surface Roughness Length, Z_o

Terrain Description	Z_o (m)
Open sea, fetch ≤ 5 km	0.0002
Open flat terrain; grass, few obstacles	0.03
Low crops, occasional large obstacles, (x/h) > 20	0.10
High crops, scattered obstacles, 15 < (x/h) < 20	0.25
Parkland, bushes, numerous obstacles, (x/h) > 10	0.50
Regular large obstacle coverage (suburb, forest)	0.5-1

x = typical distance to upwind obstacle
h = height of obstacle

The lower sensor should be located at least 1 meter above the ground. The upper sensor should be at least five times the height of the lower sensor above the lower ground. While these heights may need to be adjusted due to snow levels, ambient temperature measurements should not be taken above 10 meters.

Each instrument should be adequately ventilated by an aspirated radiation shield. If forced aspiration is to be used, then the aspiration velocity should be greater than the value of 3 meters per second (m/s). If louvered shelters are to be used at ground level, they should be oriented such that the door is facing true north. Care should be taken when using naturally aspirated shelters. Low wind speeds (i.e., less than 3 m/s) may not allow for adequate ventilation of the sensors and may lead to abnormally high temperature readings. When measuring the difference in temperature between various levels of the atmosphere, use identical radiation shields with the same amount of exposure to protect the sensors.

H.4.4 Relative Humidity Sensors

Most of the siting and exposure specifications for the relative humidity sensors are the same as those for the temperature instruments. The sensors should be shielded from the biasing effects of radiation, winds, and precipitation. Although ventilation is required to ensure proper performance of the temperature sensors, only the smallest amount of airflow is needed for the relative humidity probes. If one shelter is to be used to house both the temperature and relative humidity sensors, care should be taken to ensure that the airflow required for the former does not induce errors in measurements of the latter.

H.4.5 Radiation Sensors

Pyranometers are used for measuring incoming solar and whole sky radiation. A net radiometer measures both the incoming and outgoing radiation. Radiation measurements should be taken in areas free from obstructions and over ground that is generally representative of the site.

The sensors should have an unrestricted view of the sky at all times, with the lowest solar elevation angle possible; a tall platform or rooftop is usually the most desirable location.

Net radiometers should be mounted at least 1 meter above the ground. If the sensor must be mounted below this level, it should be located on the south side of the tower to help minimize the effects of shadows or reflections from any nearby obstructions. In addition, it is important there aren't any obstructions located above the horizontal plane of the instrument that could cast shadows on it. Net radiometers should be placed outside the influence of any upward or downward obstructions. Special care should also be taken to protect the sensing element from the biasing affects of light colored walls or other artificial sources of radiation.

H.4.6 Barometric Pressure Sensors

A barometric pressure sensor can be housed in the same enclosure as the data logger (see Section H.5). The enclosure should be well vented to the atmosphere and should be kept stocked with an active desiccant to help prevent a buildup of moisture. The site elevation should be recorded, as elevation has a strong affect upon the measured values, and the pressure should be corrected to sea level.

Refer to the owner’s manual for more information regarding a barometric pressure sensor..

H.5 DATA ACQUISITION SYSTEM

A data logger should be housed in a watertight and easily accessible shelter that is located above snow level. This enclosure should also be well vented and stocked with an active desiccant, if possible, to prevent a buildup in moisture. The door of the enclosure should face north to keep the sun out. This is especially important for temperature measurements taken during an audit. A shielded cable should be used for all of the instruments to reduce noise in the output signals, and the sensors should have the same grounding point. If possible, the instruments should be protected from lightening by using spark gapped inputs and a grounded modem.

See *On Site Meteorological Program Guidance for Regulatory Modeling Applications* for further information regarding equipment siting and installation procedures. Individual instrument manuals should also be consulted for more detailed installation instructions.

H.6 QUALITY CONTROL

The quality control aspect of a monitoring program includes periodically checking the validity of the collected data. The validation process starts with a visual inspection of the site by field office personnel and an auditor. Routine downloading and review of the data by Department of Environmental Quality (DEQ) staff also plays an integral role in the early detection of any potential problems with the instrumentation and/or data collection procedures. If the data are found to be unacceptable, they are flagged for further investigation. Table H.6.1 lists some of the screening criteria for the meteorological data. These numbers are conservative in nature and have been designed to encompass the entire range of possible values. Any measurements found to exceed these numbers should be flagged and checked at a later time.

Table H.6.1

Meteorological Data Screening Criteria

Meteorological Variable	Screening Criteria – Data Should be Flagged If:
Wind Speed	- it is less than 0 meter/second or greater than 25 meter/second - it does not vary by more than 0.1 meter/second for 3 consecutive hours - it does not vary by more than 0.5 meter/second for 12 consecutive hours
Wind Direction	- it is less than 0° or greater than 360° - it does not vary by more than 1° for more than 3 consecutive hours - it does not vary by more than 10° for 18 consecutive hours
Temperature	- it is greater than the average local monthly maximum +3 °C - it is less than the average local monthly minimum -3 °C - it is greater than a 6 °C change from the previous hour or greater than a 10 °C change in 3 consecutive hours - it does not vary by more than 0.5 °C from the previous hour - the value is greater than +50 °C - the value is less than -40 °C
Delta Temperature	- it is greater than 1 °C/100 meter during the daytime - is less than -1° C/100 meter during the nighttime - is less than -3.4 °C/100 meter (auto convective) - is greater than -3.0 °C
Stability	- it shows an A, B, F, or G stability rating during precipitation - it shows a G stability rating during the daytime - it shows an A, B, or C stability rating during the nighttime - there is a change in stability of more than 3 classes between 2 consecutive hours - it is in the same stability class for more than 12 hours
Sigma Theta (σ_θ)	- it is less than 0°C or greater than 90°C
Pressure	- it is greater than 1,060 millibars* (sea level) - it is less than 940 millibars* (sea level) - it changes by more than 6 millibars in 3 consecutive hours
Solar Radiation	- it is greater than 0 at nighttime - it is 0 (or near 0) during the daytime - it is greater than the maximum possible for that latitude and date

*These values should be adjusted for elevations other than sea level.

H.7 DATA VALIDATION

The data validation process starts with the field technician's site visit. During any site visit, whether it be a routine visit or an audit visit, the site operator **MUST** enter into the site logbook “as found” and “as left” information about any of the systems that require maintenance. This is needed to assess what data are usable.

Once a week the data should be downloaded via a modem and reviewed to help screen out any potentially invalid data points before they are put into accessible storage or passed on to the user. This is a critical activity in preventing the loss of a large amount of data since the values will often point out any existing failures in the measuring system. This duty should be the responsibility of the DEQ State Office and will entail the design and use of computer programs to screen out potentially invalid information.

Most methods for screening meteorological data involve the comparison of a measured value or set of values with an expected number or range of numbers. Some of the techniques that may be used for this purpose include:

1) comparison with an upper and lower limit on the allowed range of the data;

2) comparison with a known statistical distribution of data;

3) comparison with spatial and/or temporal data fields; and

4) comparison based upon a known physical relationship.

If questionable data points are found to exist, then errors due to faulty equipment, noisy transmission line, faulty keypunching, and a myriad of other sources should be identified and removed and the underlying problems should be identified and repaired. If a data point does not pass the validation procedure, it should be marked and stored in the data file under a flagged status. Documentation of the reasoning behind the decision to flag a data point should be included so that the user can make a decision as to its potential usefulness. As previously mentioned, Table H.6.1 provides criteria to help DEQ State Office personnel determine if the data should be flagged or not.

A computer program, designed to help screen the collected data, may be used to screen the data that is based upon the aforementioned screening criteria. This program will help to flag missing, invalid, or repeated information. Though an effort has been made to account for all of the possible errors that may occur, there may be unforeseen problems that the users may find. If this occurs, and the program cannot properly handle the problems encountered, then the user will need to manually screen the data files and report any problems to the appropriate personnel.

H.7.1 Missing Data

The short-term meteorological models presently recommended for regulatory use have not been designed to handle missing information; therefore, it is important to ensure that there is a value in each of the input fields. Substitutions for missing data should only be made to help complete the necessary data sets for modeling applications and should not be used to meet the required 90% data retrieval previously mentioned in this document. It is recommended that one of the following actions (listed in order of preference) be taken to handle such data gaps:

1) Use other representative on-site or nearby data to fill in when the primary data are missing. If data measured at a significantly different height is to be used for this purpose, then corrections, based upon known vertical profiles, should be made. Historical profiles may be used for this purpose. Replacement data collected at a significant distance from the original site in question may be used for cloud cover, mixing height, and temperature. This data may or may not be acceptable for filling in missing wind speed or direction values. The DEQ State Office should be contacted to discuss the representativeness of the data being considered.

2) If there are only one or two missing hours, then a linear interpolation of the missing values may be used. Special care should be taken in carrying out these calculations, especially when looking at the transition from daytime to nighttime or vice versa.

3) If no other source of data exists, then the missing values should be coded as a field of nines. This will flag the data as missing for regulatory applications.

H.8 QUALITY ASSURANCE

A detailed examination of the site and the data collection process is essential to help validate the data and to help detect problems that may compromise the performance of the instrumentation. Standard operating procedures to help ensure the collection of accurate and representative data should include:

1) Daily checks of the data, via modem, by the appropriate field personnel to determine instrument failure or accessibility problems;

2) Weekly site visits and visual inspections of the equipment by the field technicians;

3) Weekly reduction, screening, and validation of the data, by the appropriate DEQ State Office staff, to allow for the quick resolution of any problems;

4) Mandatory biannual (or more frequent) performance audits conducted by an independent auditor; and

5) Adequate documentation of site visits. This includes a description of the condition of the site and equipment as it was found, and a full explanation of any servicing, maintenance, or repair carried out during the visit.

   Although it may prove to be difficult, if not impossible, to conduct some of these checks on the prescribed schedule, it is recommended that they be carried out at least once a month to ensure the validity of the data collected. Each field technician should contact DEQ State Office personnel to discuss an adequate schedule.

H.9 DOCUMENTATION

In order to maintain a valid set of meteorological data, it is important to keep an accurate record of all activities that take place at the monitoring site. This includes a complete documentation of all maintenance, calibrations, and audits performed on the monitoring system. Care should be taken to record, as accurately as possible, those times when the collection of data may be disrupted due to sensor related problems. This will help when checking the validity of the data at a later time. The condition of the site and instrumentation, during each visit, should be thoroughly documented. If possible, a brief summary of the observed local meteorological conditions (i.e., falling precipitation and strong winds) should be included.

H.10 VISUAL INSPECTION

As previously mentioned, it is highly recommended that a visual inspection of the site be carried out on a weekly basis. The potential loss of valid data may prove to be detrimental to a monitoring program if a long period of time is allowed to elapse between instrumentation checks. Routine site visits will help ensure that the sensors are in relatively good condition and will allow for the verification of proper instrument performance and data collection procedures. Any instrument failures should be documented and fixed as soon as possible.

Carefully executed checks of the sensors' performance and routine data retrieval may help flag potential problems before an expensive loss of data can occur. During each site visit, a detailed description of the conditions of both the site and the instrumentation should be recorded. Any recommendations for servicing, maintenance, or repair of the equipment should also be duly noted and acted upon as is appropriate.

H.11 MAINTENANCE

Although performance audits are required twice annually, regularly scheduled maintenance checks can help to reduce future audit-related issues. Equipment maintenance, including software adjustments and hardware replacements, shall be performed according to the preventative maintenance program, or as soon as possible after equipment is noted as requiring maintenance.

H.11.1 Wind Sensor

The only components of wind sensors that are likely to require replacement due to normal wear and tear are the precision bearings and wind direction potentiometer. The sensor bearings should be replaced at least once every year, according to the manufacturer's specifications. A qualified instrument servicing facility should replace the potentiometer. If such a facility is not readily available, then the sensor should be sent back to the manufacturing company for servicing.

For more information regarding the replacement of any wind sensor components, refer to the maintenance section of the owner's manual.

H.11.2 Temperature Sensors

An aspirated radiation shield should provide adequate protection for temperature sensors under most ambient conditions. However, the shield and its components do require periodic maintenance and inspection. If a motor is used to help draw air into the shield, the motor's lifetime may be reduced at higher temperatures. As a result, the motor's performance should be checked after sustained periods of high temperatures. If any problems are detected, the motor should be replaced.

The shield should be periodically inspected for physical abnormalities and cleaned to maintain its peak performance. If a thin layer of dirt is found covering the shield, it should be washed with a mixture of mild soap and warm water. Alcohol may be utilized to remove oil from the shield, but do not use any other solvent. In addition to cleaning and inspecting the shield and motor, the mounting bolts should also be tightened periodically.

H.11.3 Radiation Sensors

The most important step in maintaining and ensuring the accurate collection of solar radiation data is to keep the sensor clean. The radiation shield should be cleaned at least once every six months. Any dust or debris found on the head of the sensor should be removed using a soft material, such as a chemical wipe or a soft bristled camel's hairbrush, to prevent scratching the probe. The drain hole, located next to the surface of the sensor, should also be visually checked for debris.

In addition to keeping the sensor clean, the instrumentation should be visually checked as often as possible and the level of the pyranometer should be checked on a monthly basis.

H.12 SENSOR CALIBRATIONS/CERTIFICATIONS

Of the meteorological sensors referred to in this document, only the wind speed and wind direction sensors are adjustable and thus able to be calibrated. The other sensors are certified initially by the manufacturer and the calibration/certification of the sensors should be checked periodically according to U.S. Environmental Protection Agency Prevention of Significant Deterioration audit criteria. One copy of the calibration/certification records should be kept in a site log, and another kept on file in the office of the field personnel.

If an accuracy check (audit) indicates suspect data, then corrective action must be taken. Corrective action can consist of:

1) calibrating the sensor (wind speed/wind direction),

2) adjusting the off-set adjustment of the data logger, or

3) returning the sensor to the manufacturer for repair or replacement.

To verify the wind direction sensor calibration,

- connect the instrument to a signal conditioning circuit that has some method of indicating an azimuth value. This may be a display that shows azimuth values in angular degrees or simply a voltmeter monitoring the output.

- Hold or mount the instrument so its center of rotation is over the center of a paper that has 30° or 45° grid markings.

- Orient the base so the junction box faces due south.

- Visually align the vane with the grid markings and observe the indicator output. If the vane position and indicator do not agree within 5°, it may be necessary to adjust the potentiometer coupling inside the main housing. To do this, refer to the manufacturer's instruction manual.

To calibrate the wind speed sensor, temporarily remove the propeller and connect a synchronous motor to the propeller shaft. Apply the following formula to convert the calibrating motor revolutions per minute (rpm) to wind speed in miles per hour (mph). Adjust the electronics for the proper value by turning the potentiometer in the appropriate direction to either raise or lower the indicated air speed. For example, with the propeller shaft turning at 3,600 rpm, adjust the indicator to display 39.5 mph (3,600 rpm x 0.01096 mph/rpm = 39.5 mph).

For each calibration, a calibration data log (site logbook entry) and calibration report should be prepared. The calibration log must include the date and time, name of person performing the calibration, name of calibration, calibration method used, where the data sheet or sheets are filed, and action taken or recommended. The calibration report should consist of a cover page, summary, and recommendations for any corrective action.

APPENDIX I: TAPERED ELEMENT OSCILLATING MICROSCALE

STATE OF IDAHO

DEPARTMENT OF ENVIRONMENTAL QUALITY

AIR MONITORING QUALITY ASSURANCE

STANDARD OPERATING PROCEDURES

FOR

AIR QUALITY MONITORING

Rupprecht and Patashnick 1400AB Continuous Ambient Particulate (PM_{10} and $PM_{2.5}$) Monitor

MARCH, 2003

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CONTINUOUS AMBIENT PARTICULATE MONITOR

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RUPPRECHT and PATASHNICK 1400AB

CONTINUOUS AMBIENT PARTICULATE MONITOR

TABLE OF ACRONYMS, UNITS, AND CHEMICAL NOMENCLATURE

AIRS	Aerometric Information Retrieval System
AQA	Air Quality Advisory
ACCU	Automatic Cartridge Collection Unit
Cm	centimeter
CFR	Code of Federal Regulations
DAS	Data Acquisition System
DOS	Data Operating System
in-Hg	inches of mercury
Lpm	liters per minute
MFC	Mass Flow Controller
Ml	milliliter
mm Hg	millimeters of mercury
NIST	National Institute of Standards and Technology
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
PM_{10} or $PM_{2.5}$	Particulate matter with aerodynamic diameter of 10 or 2.5 μm
PRC	Program Register Code
RFD	Reference Flow Device
TEOM	Tapered Element Oscillating Microscale
Mm	Micrometer
VAC	Volt, Alternating Current

Rupprecht and Patashnick 1400AB Continuous Ambient Particulate (PM_{10}) Monitor

STANDARDS: State: Federal Standards adopted by Idaho
Federal: PM_{10} Primary and Secondary
150 µg/m^3, 24 hour average (99th% averaged over 3 years).
50 µg/m^3, annual arithmetic mean.

$PM_{2.5}$ Primary and Secondary
65 µg/m^3, 24 hour average (98% averaged over 3 years).
15 µg/m^3, annual arithmetic mean averaged over 3 years.

METHOD: (TEOM) Model 1400AB. Equivalent method designation EQPM-1090-079
ANALYTE: Suspended particulate 2.5 or 10 microns in diameter
PROCEDURES: Oscillating microbalance
RANGE: 5 µg/m^3 to several grams/m^3
MANUFACTURER: Rupprecht & Patashnick Co. Inc. Albany, NY

I.1 GENERAL INFORMATION

The Tapered Element Oscillating Microscale (TEOM) is a continuous particulate monitor that received EPA Equivalent Method designation in October, 1990 for measuring the airborne concentration of particulate matter 10 micrometer (µm) in aerodynamic diameter (PM_{10}). By simply exchanging the size selective inlet, the TEOM can also be used for measuring the airborne concentration of particulate matter 2.5 µm in aerodynamic diameter ($PM_{2.5}$), but thus far the TEOM has not yet been designated by the EPA as an equivalent method for $PM_{2.5}$ monitoring.

The State of Idaho's Department of Environmental Quality (DEQ) TEOMs serve two primary functions in Idaho's particulate monitoring network:

1) monitoring for compliance determination of the 24 hour and annual National Ambient Air Quality Standards (NAAQS) for PM_{10}; and
2) for monitoring support for the Air Quality Advisory program (AQA).

Because the TEOM has not yet been designated as an equivalent method for $PM_{2.5}$ monitoring, DEQ can not use the TEOM as a $PM_{2.5}$ compliance monitor, although it will be used for AQA monitoring support. If the TEOM is designated as an equivalent method for $PM_{2.5}$ monitoring in the future, the TEOM would likely play a significant role in $PM_{2.5}$ compliance monitoring in the IDEQ air monitoring network.

I.1.1. Scope

This appendix of the Idaho Ambient Air Quality Monitoring Quality Assurance Project Plant (hereafter referred to as QAPP) covers the operation and maintenance of the Rupprecht and Patashnick (R&P) 1400AB TEOM. The information contained in this section is be supplemental to the R&P Operational Manual (hereafter referred to as R&P Manual) which should be the first source of information for the set-up, operation, and maintenance of the TEOM. This Quality Assurance (QA) Manual addresses operation and maintenance parameters that may or may not differ from the R&P Manual but highlights common functions performed by the TEOM operator, or functions that tailor use of the TEOM to meet the specific needs of DEQ's monitoring network. Where needed, this manual will reference the appropriate section of the R&P Manual for information relative to the specific section of this manual. The successful operation of the TEOM is dependant upon properly trained operators. Therefore, it is necessary that any person responsible for the daily maintenance and operation of the TEOM be fully trained by R&P or a qualified operator within the IDEQ organization.

I.1.2 Theory Of Operation

The first step of TEOM operation is particle separation which occurs by drawing a controlled volume of air (16.67 Liters per minute [lpm]) through a size selective inlet. Particle separation occurs by accelerating the airstream through a series of turns where the larger particles are removed by inertial impaction onto a sticky surface. At the exit of the inlet, the flow is split isokinetically into a 3.0 lpm and a 13.67 lpm airstream called the main flow and bypass flow respectively. The bypass flow is available for the operation of the TEOM Automatic Cartridge Collection Unit (ACCU) system. This system allows for the placement of Teflon or Quartz fiber filters in line for speciation analysis. At this time no ACCU system is being employed by DEQ so the bypass flow is exhausted to the atmosphere. The main flow, which contains the analyte fraction of particulate is sent to the instrument's mass transducer. See Figure I.2.1 for a diagram of the flow system.

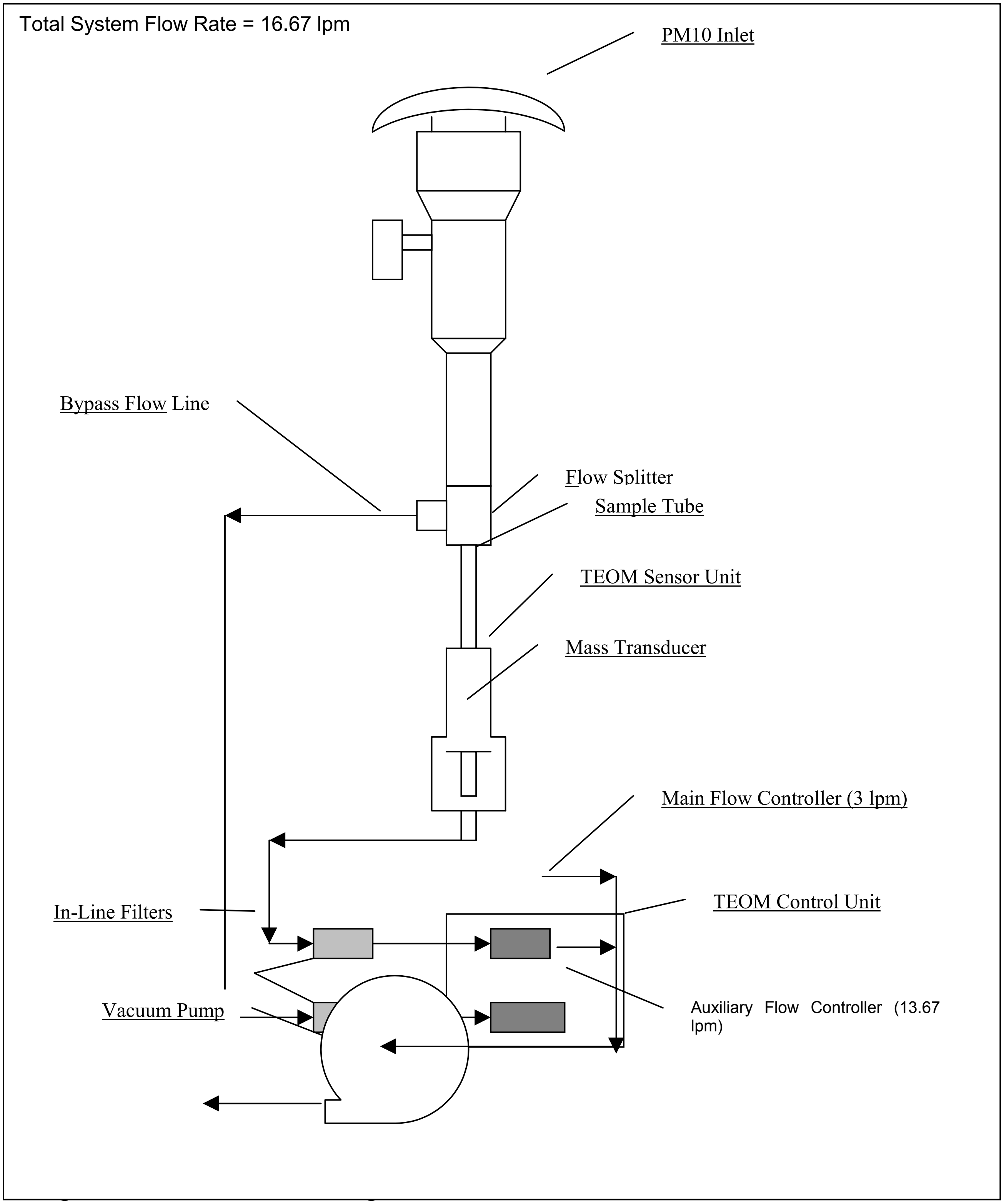
The mass transducer in the sensor unit has a thin, hollow ceramic tapered tube (or element), fixed at the downstream end, and a filter attached on the upstream end. As air is drawn through it, the element oscillates much like a tuning fork. The frequency of oscillation is dependent upon the physical characteristics of the tapered tube and the mass on its free end (i.e. the filter). As the filter continuously loads with particulate matter, the oscillation frequency of the element changes proportionally. The sensor unit monitors the oscillation frequency of the element and sends the information to the control unit where the microprocessor converts the frequency into a particulate concentration by dividing the mass rate of accumulation by the flow rate. The internal data-logger is capable of storing values in instantaneous (or real-time), 30 minute, hourly, eight hour, and twenty four hour averages.

To minimize a bias caused from atmospheric moisture, the sample stream entering the TEOM sensor unit is heated to minimize water collection on the sample filter. The operator of the TEOM must be familiar with the series of temperature controls of the sample stream. These are called the **Air**, **Cap**, **Case**, and **Enclosure** temperatures. As air is drawn into the TEOM, the sample stream (main flow) is heated at the base of the air inlet (Air temperature). The temperature of the upper part of the mass transducer (Cap temperature), the rest of the mass transducer (Case temperature), and the temperature inside the sensor unit (Enclosure temperature) are all controlled at specific temperature set-points. These temperatures will be addressed in Section I.3.3.1, Pressure and Temperature Set Points.

I.2 SITING AND SETUP

I.2.1. Siting Requirements

A TEOM site location will allow the complete installation of all TEOM components in an appropriate indoor/outdoor environment and meet siting criteria and guidelines described in 40 CFR Part 58 Appendix E, and the Quality Assurance Handbook for Air Quality Measurement Systems Volume II, Section 2.11.3.


Total System Flow Rate = 16.67 lpm
PM10 Inlet
Bypass Flow Line
Flow Splitter
Sample Tube
TEOM Sensor Unit
Mass Transducer
Main Flow Controller (3 lpm)
TEOM Control Unit
In-Line Filters
Vacuum Pump
Auxiliary Flow Controller (13.67 lpm)

A TEOM monitoring site must accommodate the installation of the TEOM components described in Sections 2 and 10 of the R&P Manual. For installation in the optional complete outdoor enclosure the primary factor of concern determining the placement of the sensor unit is the need for sturdy, vibration free mounting that will be as independent as possible from other activities in the area.

Because the TEOM operates on the principle of an oscillating element, it is sensitive to vibrations. Consideration for sources of vibration should be addressed when identifying TEOM sites. For example, sites next to roads with heavy truck traffic or rooftops sites near large HVAC, or ventilation fans should be avoided.

I.2.2 Installation

Installation of the sensor unit indoors requires:
1) a solid table, bench, counter-top, or vibration free instrument rack;
2) a straight line from the inlet of the sensor unit through a 4 centimeter (cm) diameter hole in the roof of the monitoring site;
3) tripod mounting for the inlet;
4) temperature and humidity controlled environment; and
5) accessibility to a 110 Volt, Alternating Current (VAC) power source.

Outdoor installation of the sensor unit requires:
1) a support structure free of vibration;
2) a weatherproof and temperature controlled environment; and
3) accessibility to a 110 VAC.

If the outdoor installation is located on a roof, the installation must not compromising the integrity of the roof's weatherproof surface.

Caution: Any time the sensor unit or complete outdoor enclosure is moved, the sensor unit's mass transducer must be locked to avoid damaging the tapered element as described on Page 2-7 of the R&P manual.

I.2.3. Set-Up Of Internal Data Storage

The TEOM will store up to eight of the Program Register Codes (PRCs) in the internal data logger. Each parameter is stored with the date and time. The storage interval and stored parameter configuration can be edited using the keypad or the TEOMCOMM software. Stored data can be viewed by downloading through the RS-232 port with the TEOMCOMM software either onsite or via modem.

All DEQ TEOMs are set up to store the same five data fields over a time interval of one-half hour. The additional three data fields in the DEQ TEOMs are null. Storage parameter consistency must be maintained to facilitate data retrieval through DEQ's data acquisition system (DAS). Any new TEOM put into service will follow the same data storage formats as listed in Table I.2.1. Storing 5 data fields per one-half hour line, the DEQ TEOM has an internal data storage capacity of approximately 3 months. Refer to the R&P Manual on instruction of setting up the internal data logger.

I.2.4 Analog Output

DEQ currently has no requirements for the use of the analog outputs, however, there may be circumstances when a network operator would choose to use a strip chart recorder or an external data logger. With the limited abilities of the Idaho DAS, some monitors in critical areas may need to be equipped with additional data recording devices. Having the expanded ability to track instrument operating parameters would help to ensure that collected data meets quality assurance guidelines for. Section 5 of the R&P TEOM manual addresses analog input and output specifications.

Table I.2.1
Data Storage Format

Storage Parameter	Stored Code	Stored Code Description
Storage Interval	1800	1800 seconds or one-half hour
Storage Variable 1	008	Mass Concentration
Storage Variable 2	057	30-Min Average Mass Concentration
Storage Variable 3	058	1-Hour Average Mass Concentration
Storage Variable 4	060	24-Hour Average Mass Concentration
Storage Variable 5	009	Total Mass
Storage Variable 6	Null	N/A
Storage Variable 7	Null	N/A
Storage Variable 8	Null	N/A

I.2.5 Security

In certain circumstances users outside DEQ may be viewing data stored in the TEOM's internal data logger. In these circumstances, the lock mode capabilities of the 1400AB monitor MUST BE engaged. In a lock mode, viewing of the operation of the monitor is not restricted, only the ability to change the operating parameters or operating mode is hindered. Implementing this safeguard will remove the possibility of an inexperienced individual inadvertently suspending data acquisition. Section 4.9 of the R&P TEOM manual describes the three levels of security available for the operator.

I.3 TEOM OPERATION

I.3.1 Communication

Communication with the TEOM is accomplished one of two ways. The first method is through the use of the R&P communication software called TEOMCOMM. The TEOMCOMM software is used either remotely (via modem) or on-site through the RS-232 port. The second method of communication employ's the keypad on the front of the control unit which allows the user to directly retrieve data and enter commands.

I.3.1.1 Communicating using TEOMCOMM Software

TEOMCOMM is a Data Operating System (DOS) based two-way software communication package used to view current instrument outputs, modify instrument operating parameters, and to download stored data. Also, the Idaho's DAS uses TEOMCOMM to poll the TEOMs daily, and update the data files. The TEOMCOMM software can communicate with the control unit either in the modem mode (remotely), or the direct mode (on-site) using the RS-232 port. The software utilizes PRCs to change or retrieve TEOM data directly from the control unit. The PRC's, and their associated parameters, are assigned by the manufacturer and listed in Appendix A of the R&P Manual. Some common PRCs are provided in Table I.3.1.

Serial outputs and two way communications using the TEOMCOMM software are described in Section 6 of the R&P Operating Manual.

Table I.3.1
Common Program Register Codes (PRC)

PRC	PARAMETER	EXPECTED RESULT (LIMITS)
012	Frequency	150-440 Hz
013	Noise	<0.10 g
014	Operating Mode	4
015	Case Temp. (current)	±0.1°C of set-point
021	Case Temp. (set)	±0.1°C of set-point
022	Air Temperature Set Point	±0.5°C of set-point
025	Air Temp. (current)	±0.5°C of set-point
027	Cap Temp. (current)	±0.5°C of set-point
028	Enclosure Temp. (current)	±0.5°C of set-point
029	Average Temperature	99°C
031	Average Pressure	9 atmospheres
035	Filter Loading %	>15% and < 90%
039	Main Flow (current)	1.96-2.04 l/min (±2%)
040	Auxilary Flow (current)	14.37-14.96 l/min (∀2%)
041	Status Condition	0 (signifies OK)

I.3.1.1.1 *Accessing* Teomcomm

TEOMCOMM is accessed by typing *TEOMCOMM* at the DOS prompt whereupon the main TEOMCOMM screen appears as in Figure I.3.1. To access a specific TEOM site, press F2 (Set Com Parameters) whereupon the screen shown in Figure I.3.2

appears. For all of the DEQ sites, all of the settings on the Set Com Parameters screen should duplicate those shown Figure I.3.2. Arrow down to the Phone entry and enter the telephone number for the desired site. Press *F2* again to go back to the main menu and then press *ALT D* to dial. Wait for **Modem Connection Established** to appear on the screen.

After **Modem Connection Established** appears on the screen, there are a number of common procedures the operator may want to perform. Listed below are some of the more common routines that will be performed by the operator. For other less used operating routines, refer to the R&P Manual.

Table I.3.2
TEOM, NEPH, MET DAILY OPERATING LOG
MODEM UPDATES

Date:______________ Tech:

Description	**PRN**	**SNPT**	**LMS**	**PF**	**MR**
Mass Concentration (g/m .	8				
Total Mass (g)	9				
Frequency (hz)	12				
Noise (dB)	13				
Operating Mode	14				
Current Enclosure Temp (°C)	28				
Aveage Temperature (°C)	29				
Average Pressure (atm)	31				
Filter Loading (%)	35				
Current Main Flow (lpm)	39				
Current Auxillary Flow (lpm)	40				
Status Condition	41				
30 Min. MC (g/m .	57				
1 Hr. MC (g/m .	58				
8 Hr. MC (g/m .	59				
24 Hr. MC (g/m .	60				
Time Checked:					

NEPH:

COMMENTS:

MET	**Temp (°C)**	**Wind speed (m/s)**	**Wind Direction (Deg)**	**Pressure**	**% RH**	**Battery Volts**	**Time Logger**	**Time Actual**
SPT								
CDA								
MEYER								
PIN								

I.3.1.1.2 Common Communication Routines using TEOMCOMM

1. Daily Instrument Checks. These checks are performed to check the operational parameters of the instrument or to check particulate concentrations.

   a. Call the site using the TEOMCOMM software.

   b. At the main screen, select the option *Request the Value of a Register* and enter the desired PRC.

   c. Record the PRC and it's associated value on the TEOM, NEPH, MET Daily Operating Log Modem Update Sheet (Table I.3.2 above).

   d. Deviation from the specified results shown above requires the TEOM operator perform an immediate investigation to correct the indicated malfunction. The correction may require an immediate on-site visit.

TEOMCOMM v1.1

```
Request the Value of a Register
Modify the Value of a Register
Set Instrument Mode
Download Storage
Set Storage Pointer
Fast Storage Out
Exit Program
```

F1 Help   F2 Set Com Parameters   F3 Set Station   Alt-D Dial

FIGURE I.3.1 TEOMCOMM Main Screen

TEOMCOMM v1.1a

Baud	Parity	Data
[ ] 1200	[*] None	[ ] 7 bits
[ ] 2400	[ ] Even	[*] 8 bits
[ ] 4800	[ ] Odd	
[*] 9600		
Stop	Hardware Handshake	Flow
Control		
[*] 1 bit	[*] None	[*] None
[ ] 2 bits	[ ] CTS and DSR	[ ]
XON/XOFF		
	[ ] CTS Only	
	[ ] DSR Only	
Connection	Com Port	Phone (if modem)
[ ] Direct	[*] COM1	[9,12087777649]
[*]	[ ] COM2	[ ]

F2 Save Changes

FIGURE I.3.2 TEOMCOMM Set Com Parameters Screen

2. <u>Changing the value of a PRC</u>. In certain cases, operating parameters may need to be changed. An example of this is the seasonal variation in changing of the air, cap, case, and enclosure temperature settings. To change the value of a PRC:

   a. Call the site using the TEOMCOMM software.

   b. At the main screen, select *Request the Value of a Register* and record the current value of the PRC(s) to be changed.

   c. Select *Set Instrument Mode* and select *2* (data stop).

   d. Select *Change the Value of a Register* and enter the desired numerical value.

   e. Select *Set Instrument Mode* and choose *1* (run)

   f. Select *End communications*.

   g. Record changes in equipment log book or Daily Modem Update Sheet.

   Whenever any operating parameter is changed remotely, it is recommended that the procedure is carried out at the beginning of the day to allow the operator time to check the monitor operating condition at a later time to ensure correct operation.

3. Downloading Data. Data downloaded from the TEOM is written as an ASCII file which is easily imported into a word processor or spreadsheet. To download data:

   a. Call the site using the TEOMCOMM software.

   b. At the main screen, choose *Set Storage Pointer* and enter the desired number. This will allow the operator to select the beginning of the file to be downloaded. The TEOM saves one line of data every one-half hour for 48 lines every day. Therefore, a negative 2 should be entered for each previous hour to be downloaded.

   c. At the main screen, choose *Download Data*. The software will then ask to where the file will be written. Enter the desired path and filename. If the file path and name already exist, the software will ask the user if the file is to be appended.

I.3.1.2 Communicating using the Keypad

The keypad located on the front panel of the TEOM control unit allows the user to view operational parameters and view the concentration values without the use of an RS-232 connection (laptop or modem connection). Also, all adjustable operating parameters can be changed from the keypad on the control unit.

When performing instrument maintenance, or during weekly site visits, the keypad will be utilized extensively. Sections 4.1 to 4.7 of the R&P TEOM manual describes in-depth use of the keypad and the screens associated with the keypad. Some of the more basic keypad routines are provided below.

I.3.1.2.1 Viewing Operating Conditions and Concentrations

1. Press *Main Status*. If **Main Status** is already on the main screen, a status condition message will appear saying **NO CURRENT CONDITIONS**.

2. Press *Main Status* again. You will now be at the beginning of the main screen and should see the mass concentration value displayed. (Status code, operating mode, filter loading %, and standard time will be displayed at top of screen in a header).

3. Press the down arrow to begin scrolling through operating parameters and concentration averages.

   c. *Changing Temperature Settings and/or Flow Parameters*

      1. At the main screen press *Step Screen*.

      2. Choose *Set Temps/Flows*.

      3. Scroll to the parameter needing changes by pressing the down arrow.

      4. Press *Data Stop*.

5. Press *Edit*.

6. Enter the desired numerical value.

7. Press *Enter*.

8. Press *Run*.

9. Press *Main Status* to return to the main screen.

Whenever any operating parameter is changed, it is recommended that the procedures be carried out at the beginning of the day. This allows for checking operations of the monitor at a later time to ensure correct operations. This will identify any problems that may lead to lost data due to improper maintenance procedures or instrument malfunctions.

I.3.2 Sample Filter Installation And Exchange

The TEOM must always be operated with a sensor filter cartridge (available only from R&P) installed in the mass transducer. Upon installation of the TEOM, install a filter cartridge as described in Section 3.2 of the R&P TEOM manual before supplying power to the instrument.

TEOM filter cartridges must be exchanged before the status line on the Main Screen for *Filter %* loading reaches 100%. As a warning, the **Check Status** light turns on when the filter loading is greater than 90%. The average filter lifetime depends on ambient particulate concentrations, typically two to six weeks.

a. When removing an old filter and replacing it with a new one, first push *Data Stop* on the keypad to make sure the instrument is in the Setup Mode.

b. Using the filter exchange tool provided with the instrument, gently lift the old filter from the tapered element with a straight pull. **DO NOT twist the filter**.

c. Using the filter exchange tool, place a new filter on the tapered element with slight downward pressure. **DO NOT twist the filter and DO NOT handle the TEOM filter cartridges with your fingers**.

d. Slowly close the mass transducer. The unit is spring loaded so do not slam shut.

e. Close and latch the door to the TEOM sensor unit.

f. Press *F1* or *Run* to re-start data collection.

g. Check the frequency on the Main Screen to make sure it is operating within the normal operating parameters and that the numbers to the right of the decimal point are not fluctuating rapidly. Every mass transducer oscillates at a different frequency, but generally ranges between 150 and 400 Hz.

h. Record the time and date of the filter exchange in the site log book.

I.3.3 Editing Hardware Parameters

The editing of most operational parameters can be done using the keypad or the TEOMCOMM software. Modem communication involves the use of manufacturers assigned Program Register Codes (PRC). The complete inventory of PRC codes are listed in Appendix A of the R&P Manual.

I.3.3.1 Pressure and Temperature Set Points

DEQ currently changes the airstream temperature set points of all operating TEOMs twice yearly. The airstream temperatures from October 1 through March 31 differ from the airstream temperatures from April 1 through September 30 as shown in Table I.3.3. This modification is intended to reduce volatilization of the light hydrocarbon compounds and thus provide better correlation of the data with conventional gravimetric PM_{10} measurement methods. For more information, see R&P's Technical Note #4, dated October 1993.

The keypad or TEOMCOMM can be used to change the air, cap, case, and enclosure temperatures. To change the airstream temperatures using TEOMCOMM, follow the procedure described in Section I.3.1.1, *Communicating using TEOMCOMM Software*. Changing the value of PRCs 021, 022, 023, and 024 for Case, Air, Cap, and Enclosure temperatures respectively, is required twice annually.

To change the airstream temperatures using the keypad, follow the procedure described in Section I.3.1.2, *Communicating using the Keypad*, for the same PRCs mentioned above. The changing of temperature and pressure set points and other hardware parameters are discussed on Pages 4-20 and 4-21 of the R&P manual.

The IDEQ 1400AB TEOMs are equipped with ambient temperature and pressure sensors and self compensating flow controllers. Because of this, the average temperature and average pressure used in flow calculations (PRC #s 029 and 031) DO NOT need to be changed but they do need to be set initially. The initial settings are codes assigned by R&P, and their values are shown in Table I.3.4.

Table I.3.3

IDAHO TEOM-SEASONAL TEMPERATURE SET-POINTS			
	PRC	OCT 1 - MAR 31 SETTING	APR 1- SEPT 30 SETTING
CASE Temperature	021	30.00	50.00
AIR Temperature	022	30.00	50.00
CAP Temperature	023	0.00	50.00
ENCLOSURE Temperature	024	25.00	40.00

Whenever an operating parameter is changed it is recommended that the procedures be carried out at the beginning of the day if possible. This allows for checking operations of the monitor at a later time to ensure correct operations. This will identify problems that may lead to lost data due to improper maintenance procedures or instrument malfunctions. It is also recommended that all changes be completed before new hour starts.

Table I.3.4
R&P Provided PRC Set-Points

PRC	Description	Setting
029	Average Temperature, used in flow calculations	99
031	Average Pressure, used in flow calculations	9

I.3.3.2. TEOM Clock

Idaho straddles two time zones, the Pacific Standard Time zone and the Mountain Standard Time zone. The TEOMs will always be set on standard time and WILL NOT be set on daylight savings time. The TEOM clock should be checked with every site visit. Do not allow the TEOM clock to drift more than ±15 minutes from standard time.

I.3.3.3. Operation After a Power Failure

All TEOM operating parameters including the clock and calendar are maintained in a battery backed-up memory. Upon regaining power, the instrument waits for temperatures and flow rates to remain stable for one-half hour before automatically resuming data evaluation. A cursory inspection of monitoring hardware and associated peripherals should be performed following a power outage. The inspection will help to determine if any damage was sustained to the monitor, modem, or other components. The operator should also check that system installation is not to blame for the power problems.

I.3.3.4. Log Book Requirements

All DEQ TEOM data reporting stations are required to maintain site specific instrument log book. The log book(s) should be hardbound, with numbered pages. It will be used as an official record for documenting all TEOM maintenance activities, quality control checks, site visits, and data transfers. The following is the minimum required log book documentation:

a. Site visits.
   1. Date, TEOM time, and actual time.
   2. status condition and operating mode
   3. filter loading (%).
   4. main and auxiliary flows.
   5. noise and frequency.
   6. mass concentration (at minimum the instantaneous value).
   7. enclosure temperature.
   8. operator’s initials

b. Maintenance and Quality Control (QC) checks.
   1. activities.
   2. results of checks, etc.
   3. operators initials.

c. Data transfer
   1. activities.

2. operator's initials.

d. Remote modifications via modem
   1. recorded on Daily Modem Update Sheet.

I.3.4 Data Handling

The Idaho DAS at DEQ's State Office in Boise, daily polls the data stored by the TEOMs internal data logger. The DAS stores the polled data in Aerometric Information Retrieval System (AIRS) format which is downloaded by an Air Quality Monitoring Analyst in the DEQ State Office onto a diskette. The data on the diskette is then downloaded into the AIRS database. The Air Quality Monitoring Analyst or the DEQ Meteorologist at the DEQ State Office reviews the data daily to insure complete acquisition of all the sites, and to check pollution levels for the AQA program.

To serve as a backup to the AIRS formatted data, approximately every two weeks the Air Quality Monitoring Analyst also acquires the data separate from the DAS by downloading the data directly using the TEOMCOMM software. The backup data acquired using TEOMCOMM is stored as an ASCII file in the following format:

DATE	TIME	NULL	PRC	INST	PRC	□ Hr	PRC	1 Hr	PRC	24 Hr	PRC	TOTAL MASS
06-Apr-98,	00:07:05,	000,	8,	38.5,	57,	44.5,	58,	51.9,	60,	37.7,	9,	758.55
06-Apr-98,	00:07:35,	000,	8,	32.2	57	42.6	58	50.7	60,	35.5,	9,	758.63
06-Apr-98,	00:08:05,	000,	8,	32.2	57	42.6	58	50.7	60,	35.5,	9,	758.63
06-Apr-98,	00:08:35,	000,	8,	32.2	57	42.6	58	50.7	60,	35.5,	9,	758.63

Where:

a. PRC = Program Register Code (an identifier code assigned by R&P).
b. INST = Instantaneous concentration (g/m^3).
c. □ Hr = □ hour concentration (g/m^3).
d. 1 Hr = 1 hour concentration (g/m^3).
e. 24 Hr = 24 hour concentration (g/m^3).
f. TOTAL MASS = total mass loading on filter (g).

Each regional office must also download the data approximately every two weeks from the TEOMs in their region as an ASCII file using TEOMCOMM.

I.3.5 Data Review And Validation Requirements

Before the 15th of each month, the Air Quality Monitoring Analyst at the DEQ State Office will print a copy of the AIRS formatted data for the previous month from the DAS. The monthly printout will include the 1 hour and 24 hour averages and will be mailed to the respective regional office. Within four weeks after receiving the monthly printout, the following DEQ personnel will:

a. Regional Office - will review and make copies of all entries into the TEOM logbook which include maintenance, filter exchanges, audits, etc.

b. Regional Office - will make copies of the Daily Modem Update Sheets. Document, or flag, these occurrences on the monthly printout. Confirm anomalous data periods with the instrument logbook entries. Look for 24 hour average values that are registered as zeros. Restarting the instrument causes the 24 hour average to restart. Consequently, a zero for a 24 hour average indicates that the TEOM had either some malfunction such as a power outage or some sort of user interaction. Reconcile any data interruptions with the log book or daily modem update sheet.

c. Regional Office - mark the monthly printout appropriately for invalid or anomalous data. Negative TEOM values will be dealt with according to the policy described in the Section I.3.6, Special Data Handling Issues.

d. Regional Office - mail the copies of the logbook entries and the Daily Modem Update Sheets to the DEQ State Office along with the monthly data printout.

e. State Office - review the documentation received from the Regional Office. Any changes that need to be made will be edited on the DEQ DAS.

f. After all editing is finished, three copies will be printed. Each copy will be marked Final-As Entered in DAS in the upper right hand corner. The copies will be filed as follows:

1. Log sheets, the daily modem update sheet, the original copy of the monthly printout, strip charts (if applicable) and one final copy of the monthly printout will be filed in the DEQ State Office Files.

2. One copy of the final monthly printout will be filed in the hanging files in the DEQ DAS room.

3. One copy will be mailed to the appropriate Regional Office.

I.3.6 Special Data Handling Issues

Since the TEOM operates using an oscillating element, it tends to be sensitive TO vibrations. Vibration from nearby traffic, roof fans, or other sources can cause aberrant fluctuations in the data. Because of this, the data printouts will often show negative numbers. The AIRS database will not accept negative particulate concentrations, so the negative numbers must be corrected, or flagged. The minimum detectable limit of the TEOM is ±10 nanograms. The DEQ policy will be that any datum less than -1 $\mu g/m^3$ will be deleted and a null code of 9979 (miscellaneous void) inserted. Any datum between 0 $\mu g/m^3$ and -1 $\mu g/m^3$ will be changed to zero.

I.3.7 Data Assessment

At all DEQ TEOM sites where there exists a collocated PM_{10} high volume reference sampler, linear regression analyses will be performed to determine equivalent vs. reference methods comparability and to assess TEOM data quality. The regressions will be performed monthly, quarterly, and annually for data spanning the calendar year. The results of each regression analysis will be forwarded to central office personnel for review.

A regression will be setup where the independent (x) variable is the 24 hour average TEOM data, and the dependent (y) variable is the high volume reference sampler data. The r^2 value should be noted. With this same set of data, concentration differences, percent differences, and a correlation coefficient should be calculated. Anomalous data points must be investigated for validity by the TEOM operator.

I.4 MAINTENANCE

Routine service will be performed as needed with increased service at quarterly, semi-annual, and annual intervals. Troubleshooting monitor malfunctions or unusual operating parameters will be performed as needed. Requirements for maintenance are usually site specific and vary from one location to another. Users should be familiar with Appendices C-F and Sections 7 and 8 of the R&P manual before attempting any maintenance of a TEOM monitor.

I.4.1 Monthly Inspections And Maintenance

Perform the following inspection and maintenance operations on a monthly basis to retain the equipment’s ability to provide quality data. Some of these inspections will not generate maintenance activities each month, but early detection and rectification of potential problem areas will yield high quality operations, less lost data, and more equipment operating time. As with any schedule the frequency will vary slightly due to local sampling conditions.

I.4.1.1 Cleaning the Inlet

It is necessary to clean the impaction plate and accelerator assembly of the inlet at each sensor filter exchange.

a. After replacing the filter cartridge in the mass transducer, carefully remove the PM_{10} or $PM_{2.5}$ inlet assembly from the inlet tube.

b. Separate the collector assembly from the accelerator assembly.

c. Clean the impaction plate (collector) using a general purpose cleaner. Clean the bottom, walls, and three vent tubes of collector.

d. Coat the impaction plate with silicon impactor grease.

e. Dismantle the top plate from the accelerator assembly and remove the insect screen.

f. Clean the accelerator tube using a general purpose cleaner.

g. Reassemble the screen and the top plate and re-install them onto the collector assembly.

h. Carefully replace the PM_{10} or $PM_{2.5}$ inlet assembly on inlet tube.

I.4.1.2 Replace In-Line particulate filters

It is critical for proper operation that the Mass Flow Controllers (MFCs), located inside the TEOM control unit, remain free of particulate contamination. This is done by replacing the in-line particulate filters when they show signs of becoming loaded with particles. The in-line filters must be replaced before the filters become plugged, preventing adequate flows. In most circumstances this corresponds to an exchange every six months, however, local conditions will determine this schedule.

a. Press *data stop* to take the TEOM offline.

b. Remove the vacuum pump source from rear of the TEOM.

c. Remove the large bypass line filter or the two small filters on the rear panel of the TEOM.

d. Replace the old filter(s) with the new filter(s), installing them with the arrow on the filter(s) pointing against the direction of flow. (This is done to aid in the determination of a fully loaded filter).

e. Replace the vacuum line.

f. Reset the TEOM to run.

g. Perform a systems leak test after connecting the new filters into the flow lines.

I.4.1.3 Vacuum Pump Check

The TEOM requires a minimum vacuum pressure to operate properly. Checking it periodically will help to identify a problem before large blocks of data are invalidated.

a. Press *data stop* to take the TEOM offline.

b. Disconnect the vacuum line.

c. Install a portable vacuum pressure gage in the vacuum line.

d. Record the vacuum (usually in inches of mercury) reading in the site log book.

e. Remove the vacuum gauge and re-connect the vacuum line.

f. Reset the TEOM to run mode.

When the pump vacuum falls below 20 inches of mercury (in-Hg) and /or cannot maintain a consistent flow rate, repair or replacement of the pump is necessary.

I.4.2 Quarterly Maintenance

The scheduled maintenance items listed below are required on a quarterly basis for the proper operation of the TEOM. As with any schedule the frequency will vary slightly due to local sampling conditions.

I.4.2.1 Main and Auxiliary Flow System Check

Maintaining the correct flow rates through the system is essential to the proper operation of the TEOM and the subsequent determination of particulate concentrations. Two separate flow streams are utilized in the TEOM configuration. Both are critical to the operation of the TEOM inlet and mass transducer systems. An independent performance audit of each TEOMs flow rate is required at least once annually. DEQ performs flow audits on a quarterly schedule. Operating personnel will perform a flow check of the system between each audit at a time that is prudent and convenient. (Usually after a sensor filter exchange or other maintenance procedure). Refer to section 8.6 of the R&P Manual for complete instruction.

I.4.2.2 System Flow Check

a. Press *data stop* to take the TEOM offline.

b. Remove the PM_{10} or $PM_{2.5}$ inlet from the inlet tube and install the reference flow device adapter to the TEOM inlet tube.

c. Connect the reference flow device to the adapter and take a measurement of the flowrate. Measuring the flowrate at this configuration determines the reference device flowrate for ***total flow*** of TEOM system. The total flow should be 16.67 lpm ±10%.

d. Remove the auxiliary flow line (the green tube) at the flow splitter and fasten the compression cap to seal the splitter connection.

e. Determine reference device flow for main (sample) flow of TEOM system. The sample flow should be 3.0 lpm ±10%.

f. Calculate auxiliary flow rate from two flows obtained in steps 4 and 6.

g. Calculate percent difference of reference flows to TEOM displayed flows and record in sites log book.

h. Reconnect the auxiliary flow line to the flow splitter.

i. Remove the flow adapter and replace the PM_{10} or $PM_{2.5}$ inlet.

I.4.2.3 Leak Test

After performing any maintenance activity that involves the removal and reconnection of the flow system hoses, a leak check is necessary. If no maintenance involving hose disconnection is conducted during a quarter it is recommended that a leak check be performed during the flow check. Refer to section 7.6 in the R&P manual for complete instruction.

a. Place the TEOM in the data stop mode.

b. Remove the PM_{10} or $PM_{2.5}$ inlet assembly from the inlet tube.

c. Install the reference flow device (RFD) adapter to the TEOM inlet tube.

d. Slowly close the adapter petcock until all flow is stopped.

e. Check the TEOM display. As you watch the display, you should notice the flowrate dropping close to or less than zero which indicates an airtight system. If the flow rates do not drop close to or less than zero the operator will have to troubleshoot to identify the leak (if the TEOM display indicates an auxiliary flow rate of greater than 0.15 actual lpm, or a main flow rate of greater than 0.15 actual lpm, then check for leaks).

f. SLOWLY open the flow adaptor petcock to prevent sensor filter damage, until the flow is restored.

CAUTION: Opening the flow adapter too quickly could damage the filter.

g. Remove the flow adapter and replace the inlet assembly.

I.4.3 Semi-Annual Maintenance

The scheduled maintenance items listed below are required on a semi-annual basis for the proper operation of the TEOM. As with any schedule, the frequency will vary slightly due to local sampling conditions. Relatively dirty air sheds will require more frequent maintenance activities than relatively clean air sheds.

I.4.3.1 Cleaning the Air Inlet System

The inlet system is susceptible to particulate buildup on the inner walls of the inlet tube. The manufacturer recommends cleaning the inlet tube twice a year. Refer to section 7.5 in the R&P manual for complete instructions.

a. Turn off the control unit.

b. Remove the air thermistor from the cap.

c. Pivot the microbalance into its open position.

d. Protect the mass transducer with plastic wrap or other protective material.

e. Using mildly soapy water and a soft brush, clean air inlet inner walls.

f. Allow inlet to dry.

g. Remove the plastic wrap protection from microbalance and return the microbalance to its closed position.

h. Re-insert the thermistor.

i. Turn on the control unit.

I.4.3.2 Mass Flow Controller(s) Calibration (software)

Calibration of the mass flow controllers can be accomplished simply without having to adjust any hardware. The software procedures allow the user to calibrate with the touch pad interface. Refer to section 8.2 in the R&P manual for complete instruction.

a. Turn off the control unit.

b. Disconnect the electrical cable that links the control unit to the mass transducer.

c. Turn on the control unit.

d. Select Set Temps/Flows screen and scroll to F-Aux and F-Main, record the set points for the main and auxiliary flows.

e. Scroll to T-A/S P-A/S and record the existing values, then set them to current conditions.

f. Scroll to F-adj Aux and □F-adj Main.

g. Attach a reference flow meter to the Sensor Flow location on the back of control unit.

h. Compare the value of the reference flow meter to the TEOM value, edit the value of F-adj Main until the flow shown on the reference flow meter match those recorded in step 4.

I. Repeat steps 7-8 using the port marked Auxiliary Flow on the back of the control unit.

i. Return T-A/S and P-A/S to the original values recorded in step 5.

j. Turn off the control unit.

k. Make sure the air lines are re-inserted into proper locations at the back of the control unit.

l. Re-connect the electrical cable that links the control unit to the mass transducer.

m. Turn on the control unit.

I.4.4. Annual Maintenance

The scheduled maintenance items listed below are required on an annual basis for the proper operation of the TEOM. As with any schedule the frequency will vary slightly due to local sampling conditions.

I.4.4.1 Calibration (hardware) of Mass Flow controller(s)

The TEOM comes equipped with either a Brooks flow control system or a Tylan flow control system. Both MFCs are easily calibrated using certified flow transfer standards equipment. The following procedures are generic. Refer to section 8.4 in the R&P manual for complete instruction.

a. Turn off the control unit.

b. Disconnect the electrical cable that links the control unit to the mass transducer.

c. Remove the top cover of the control unit.

d. Position the MFC bracket for easy access.

e. Turn on the control unit.

f. Scroll to T-A/S P-A/S and record the existing values, then set them to current conditions.

g. Ensure that the software flow adjustments are set to 1.00.

h. Attach the reference flow meter to the Sensor Flow location on the back of the control unit.

i. Close off the vacuum source to stop all flow to the MFC.

j. Adjust the zero potentiometer on the main flow MFC until a zero reading is shown on the TEOM display.

k. Set the flow set-point to full scale of the MFC (should be 5 lpm).

l. Open the vacuum pump source to allow complete air flow.

m. Adjust the gain potentiometer on the main flow MFC until a full scale reading is shown on the TEOM display.

n. Repeat steps i-m until both the zero and the full scale value are correct without further adjustments.

o. Repeat steps h-n using the Auxiliary Flow port and the MFC.

p. Return T-A/S and P-A/S to the original values recorded in step f.

q. Turn off the control unit.

r. Make sure the air lines are re-inserted into the proper locations at back of the control unit.

s. Re-connect the electrical cable that links the control unit to the mass transducer.

t. Turn on the control unit.

I.4.4.2. Analog Calibration

R&P suggest an annual calibration of the analog input/output. It is further recommended that this procedure be completed prior to the mass flow calibration. Given the complexity of calibrating the analog input and outputs and the limited scope of this QA document, refer to section 8.3 in the R&P manual for complete instruction.

1.4.4.3 Mass Transducer Calibration Verification

The DEQ does not at this time employ the procedure of mass transducer calibration verification. According to the manufacturer, using the TEOM under normal circumstances the calibration does not change materially over the life of the instrument.

I.5 MISCELLANEOUS ITEMS

I.5.1. Spare Parts and Equipment on Hand

The following is a recommended list of spare parts and equipment that the operator should have on hand to perform as needed repairs and maintenance activities.

- 1 vacuum pump motor
- 1 vacuum pump motor rebuild kit
- 2 large in line particle filters
- 4 small in line particle filters
- 1 box sensor filters
- 10 feet auxiliary and main flow line
- 1 bottle cleaning solution
- 1 box lint free wipes or similar towels
- 1 small brush

I.5.2 Recommended Tools and Equipment

The following is a recommended list of tools and equipment that the operator should have on hand to perform as needed repairs and maintenance activities.

- digital multi meter
- BIOS flow calibrator or similar flow measuring device
- temperature and pressure indicator
- calculator
- various hand tools (screwdrivers, wrenches, small sizes, etc.)
- R&P TEOM operating manual
- inlet flow adapter
- gun cleaning kit for sample line cleaning

I.6 TEOM AUDITS

I.6.1 Objectives and Guidelines

The primary objective of an auditing program is to identify system errors that may result in suspect or invalid data. A true assessment of the accuracy of a PM_{10} measurement system can only be achieved by conducting an audit under the following guidelines:

a. Without special preparation or adjustment of the system to be audited.

b. By an individual with a thorough knowledge of the instrument or process being evaluated, but not by the operator.

c. With accurate, calibrated National Institute of Standards and Technology (NIST) - traceable transfer standards that are completely independent of those used for routine calibration and QC checks.

d. With complete documentation of audit information for submission to the operating agency. The audit information includes, but is not limited to, types of instruments and audit transfer standards, instrument model and serial numbers, transfer standard traceability, calibration information, and collected audit data.

e. The audit procedure described in this section outlines the steps for implementing a performance audit for the Rupprecht and Patashnick Series 1400AB TEOM PM_{10} monitor operated in the State of Idaho by DEQ.

f. Two instrument flow rates are challenged with a calibrated transfer standard volumetric flow meter (e.g., BIOS DC-1 flow calibrator). The <u>actual instrument flow rate</u> (nominally 3 lpm) is measured with the transfer standard and reported for accuracy. The <u>total flow rate</u> is also checked to verify that it is within the ±10 % tolerance specified for the PM_{10} inlet, but total flow rates are not reported for accuracy. The instrument clock is checked to verify it is within ±15 minutes of Standard Time. The temperature sensor is challenged with a NIST traceable thermometer to verify it is within ±2 °C. The pressure sensor is challenged with a NIST traceable barometer to verify it is within ±10 in Hg of the audit measurement.

Definitive procedures are not established for the use of calibration foils or standard filters for determining the accuracy of mass measurements (i.e., oscillation constant, K_o), and are not included in this procedure.

I.6.2. Audit Procedure

The auditor shall adhere to the following procedures during the audit of the TEOM PM_{10} sampler:

I.6.2.1 Equipment

Transport the following equipment to the monitoring site:

a. Certified (NIST traceable) transfer standard volumetric flow meter (e.g., BIOS DC-1 with cells DC-1-SC and DC-1-HC).

b. Flow audit adapter to connect the transfer standard outlet to the sampler inlet, with enough 3/8 inch vacuum tubing for the connection (about five feet).

c. 3/8 inch Swagelock cap.

d. Adjustable wrench.

e. A watch or clock calibrated to Standard Time.

f. Certified transfer standard (NIST traceable) for measuring ambient temperature, with an accuracy of ±2 °C over the range of -30 to 45 °C and a resolution of 0.1 °C.

g. Certified barometer (NIST traceable) for measuring ambient barometric pressure, with an accuracy of ±5 millimeters of mercury (mm Hg) over a range of 600 to 800 mm Hg and a resolution of 1 mm Hg.

h. A TEOM Audit data worksheet (Figure I.6.1).

I.6.2.2 Method

a. Ensure the TEOM is offline from the data logger. Instruct the operator to scroll the display on the control unit to the main (actual) and auxiliary (bypass) flows. The display represents the indicated actual volumetric flows (Q_a) measured by the monitor's flow controllers.

b. Record the time on the control unit display on the audit data worksheet. Verify that it is within ±15 minutes of Standard Time.

c. Position the audit transfer standard within reach of the sampler inlet. Carefully remove the PM_{10} inlet, and install the flow audit adapter.

d. Connect the audit flow adapter to the outlet nipple of the DC-1-HC flow cell (50 ml to 50 lpm) with vacuum tubing and insert the cell to the BIOS DC-1 base. Allow the flow to stabilize for a minute or two. Connect the printer to the BIOS. Turn both the printer and the BIOS power to ON. On the BIOS base, depress the mode button, and while holding it down, press the read button. The BIOS will measure and record ten successive flows and provide an average of the ten flows. If the ten measured flows show a great deal of variability, repeat the process.

e. The average of the ten measurements is the audit <u>total</u> flow (Q_a). Record this value on the audit data worksheet. The audit total Q_a must be within ±10 % of the sampler's design flow , nominally 16.7 lpm, to be acceptable. If it is out of tolerance, check for leaks and recalibrate if necessary.

f. Record the sampler's indicated total Q_a (sum of auxiliary and main flow) from the control unit on the audit data worksheet.

g. Calculate the percent difference of the sampler's indicated total Q_a from the audit total Q_a, and record on the audit data worksheet using Equation (1):

$$\%\,Difference = \frac{Display\ Q_a\ \text{-}\ Audit\ Q_a}{Audit\ Q_a\ x\ 100\%} \qquad \text{Equation (1)}$$

h. Disconnect the bypass flow line where it connects to the flow splitter. Cap the exit of the flow splitter with the 3/8 inch Swagelock cap.

i. Replace the DC-1-HC flow cell with the DC-1-SC (10 ml to 9.999 lpm) cell and connect the vacuum tubing to the outlet nipple. Allow the flow to stabilize for a minute or two. Repeat the measurement process described in step d.

j. The average of the ten measurements in the audit actual Q_a. Record this value on the audit data worksheet. The audit actual Q_a must be with ±10 % of the sampler's design main flow (actual flow), nominally 3 lpm, to be acceptable. If it is out of tolerance, check for leaks and recalibrate.

k. Record the sampler's indicated actual Q_a from the control unit on the audit data worksheet.

l. Calculate the percent difference of the sampler's indicated actual Q_a from the audit actual Q_a using Equation (1), and record on that audit data worksheet.

m. If the sampler's indicated total flow is not within ±10 % of the total audit Q_a, investigate. If the sampler's actual indicated Q_a is greater than ±10 % of the audit actual Q_a, all data collected subsequent to the last calibration or audit may be subject to invalidation. Before invalidating any data, double-check the audit transfer standard's certification and all calculations.

n. Have the operator scroll to the screen with ambient temperature and pressure. Ambient pressure (P_a) will be displayed in atmospheres of pressure. This value multiplied by 760 mm Hg (1 atm = 760 mm Hg) will give you ambient pressure in mm Hg. The ambient temperature (T_a) will be displayed in °C. Record the sampler's indicated P_a and T_a on the audit data worksheet.

o. Record the measured audit P_a and T_a on the audit data worksheet. Calculate the pressure and temperature differences, Sampler - Audit P_a and T_a, on the audit data worksheet. Any difference in ambient pressure greater than 10 mm Hg shall be reported for corrective action. Any differences in ambient temperature greater than 2 °C shall be reported for corrective action.

This completes the audit. Remove the audit flow adapter, replace the PM_{10} inlet and instruct the operator to place the sampler back online.

I.6.3 Audit Data Reporting

The operating agency should be given a copy of the audit preliminary results at the completion of the audit. The audit data sheet should be signed by both the auditor and operator, and the results should be discussed. A post-audit verification of audit equipment and data is essential before inferences can be drawn regarding the sampler's performance. The auditor should be able to support audit data with equipment verification documentation.

Final verified audit data shall be submitted to the operating agency as soon as possible. If a sampler exhibits unsatisfactory agreement with the verified audit results, a calibration shall be performed as soon as possible.

I.6.4 Audit Frequency

For State and Local Air Monitoring Stations (SLAMS), flow rate audits shall be conducted on at least 25 percent of the operational samplers in the monitoring network each quarter such that each sampler is audited at least once a year. If there are fewer than four TEOM PM_{10} monitors in the network, re-audit one or more randomly so that one is audited each calendar quarter.

Quality Assurance Audit of TEOM PM_{10} Sampler
for Department of Environmental Quality

Auditor ___________________________ Organization

Site ______________________________ Sampler Model _____________ S/N

Date ______________________________ Time

Flow Audit Transfer Standard:
Pressure Audit Transfer Standard:
Temperature Audit Transfer Standard:

Flow Type	TEOM Indicated Q_a, (lpm)	Audit Q_a, (lpm)	Q_a % Difference[1] ±	Design Difference[2] ±
Total (main + auxiliary, nominally 16.7 lpm)				
Actual (main, nominally 3 lpm)				

Sampler's Indicated T_a, °C	Audit T_a, °C	Difference, °C (Sampler - Audit)	Sampler's Indicated P_a, mm Hg	Audit P_a, mm Hg	Difference, mm Hg (Sampler - Audit)

Standard Time

TEOM time on digital display

Time difference

[1]Q_a percent difference = [(Sampler Q_a - Audit Q_a)/Audit Q_a] x 100

[2]Design percent difference = [(Audit Q_a - Design Q_a)/Design Q_a] x 100

Figure I.6.1. TEOM Audit Data Worksheet

APPENDIX J: NEPHELOMETERS

STATE OF IDAHO

DEPARTMENT OF ENVIRONMENTAL QUALITY

AIR MONITORING QUALITY ASSURANCE

STANDARD OPERATING PROCEDURES

FOR

AIR QUALITY MONITORING

RADIANCE RESEARCH MODEL M903 INTEGRATING NEPHELOMETER

MONITORING, MODELING, AND EMISSIONS INVENTORY

MARCH 2003

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Radiance Research Model M903 Integrating Nephelometer

Radiance Research Model M903 Integrating Nephelometer

Acronyms, Units, And Chemical Nomenclature

DC	Direct Current
DEQ	Department of Environmental Quality
lpm	Liters per minute
nm	Nanometer (10^{-9} meter)

Radiance Research Model M903 Integrating Nephelometer

STANDARDS:

State: Not Applicable

Federal: None

METHOD:

An integrating nephelometer estimates the scattering coefficient of light (b_{scat}) caused by aerosols and gases in ambient air. The light scattered from an internally tube-mounted flashing light source is integrated from 5 to 175° deflection and measured by a photodiode detector at the opposite end of the tube.

PRINCIPLE: Integrating nephelometer

RANGE: 0.001 to 1.0 km^{-1} with a time constant of 30 seconds

DETECTION LIMIT: < 0.001 km^{-1} with a time constant of 30 seconds

WAVELENGTH: 475 nm

MANUFACTURER: Radiance Research

J.1 OPERATING PRINCIPLE

An integrating nephelometer measures the scattering coefficient of light (b_{scat}) caused by maintaining a steady ambient airflow rate through an optical tube. The optical tube contains a variable rate flash lamp with a wavelength limiting optical filter of 475 nanometers (nm). At the opposite end of the tube is a photodiode detector that measures light scattered by aerosols and gases in the nephelometer's tube. Light reflected from the inside surfaces of the instrument optical chamber is also measured and integrated into the overall signal strength. The inside reflective component is constant and corrected for by performing zero and span calibrations.

Directly across the optical tube a second photodiode detector measures the output level of light from the lamp. This compensates for any changes in lamp brightness due to power supply changes, lamp aging, and dust on optical surfaces.

The Radiance Research nephelometer is computer based with a menu driven display and toggle switches for control. A serial port is included with the instrument to communicate with an external computer. An internal random access memory (RAM) with battery backup allows for data storage. A nine-pin connector labeled "analog output" can be utilized to collect nephelometer data on a separate datalogger. A constant speed exhaust fan ensures adequate airflow through the system. A purge port is included with the instrument to facilitate calibrations.

J.1.1 Siting Criteria

According to the *Interagency Monitoring of Protected Visual Environments (IMPROVE) Visibility Monitoring Guidance Document* (Draft) (Air Resource Specialists, Inc. 1998), nephelometer siting criteria include selecting a location representative of the air mass of interest to the project. Three monitoring definitions (local, regional, and national/global) are used to classify siting for specific monitoring objectives. Because of the localized measuring technique involved with the nephelometer, local measurements are most common. However, a regional approach may be accomplished through the use of multiple monitors.

The unit should not be installed in an area of localized pollution sources (e.g., vehicles, smoke, fugitive emissions, etc.). The site shall be located at least 2.5 times the difference in heights from the nearest obstruction. The nephelometer shall also be installed so that the sample is collected with minimal probe length. The site shall be selected so that vandalism will be minimal, but monthly access not impeded.

J.1.2 Installation and Site Documentation

The nephelometer shall be installed in a temperature-controlled environment with a bug/large particle inlet screen. A temperature and relative humidity sensor should be located on a nearby meteorological tower. A datalogger and a calibration system shall also be employed. A 120-volt AC power source shall be made available along with a telephone line and modem for data collection. After installation, the nephelometer shall be calibrated and the system data collection verified. All operators and auditors shall be trained on the operation of the various components. The site shall then be fully documented by completing a site documentation report. The report should include photographic documentation of the following:

- the site,
- electrical wiring,
- local emission sources,
- obstructions, and
- vistas.

The report should also include a site map and geographic coordinates with elevation and the nearby land usage.

J.2 VERIFICATION, SERVICE, AND CALIBRATION

The quality of data collected is a direct result of the level of nephelometer servicing, frequency of site visits, and instrument calibrations.

J.2.1 Daily Modem Operation Checks

Contact the nephelometer daily to check if the instrument is operating within specifications.

J.2.2 Routine Servicing

J.2.2.1 Weekly Site Visits

1) Inspect the nephelometer hardware and installation components.
2) Verify that the system has power.
3) Check the system clock(s).
4) Check the condition of the inlet screen and exhaust fan.
5) Perform a zero and span check; recalibrate if necessary.
6) Document any abnormalities with the system.

J.2.2.2 Monthly Site Visits (Every Fourth Week)

1) Assemble monthly zero and span checks for the control charts.

J.2.2.3 Annual Site Visits (as needed)

1) Document the initial condition of the instruments and site.
2) Verify system operation with a zero and span check.
3) Perform a complete calibration of the system.
4) Perform a site inventory
5) Service (clean) or exchange the nephelometer, temperature, and relative humidity sensors (if applicable).
6) Verify serviced or exchanged systems with a complete calibration.

J.2.3 Instrument Verification

A method for verifying that the nephelometer is working correctly is executing a Zero/Span check. The instrument should perform acceptably, yielding an adequately precise zero value, and a span value of 95 ±5% of full scale. Additionally, the analog output, or other data communication/recording devices, shall provide the appropriately scaled values for zero and span checks.

J.2.4 Calibration Procedure

The procedures for the zero/span checks and complete calibrations are similar.

1) Apparatus
    a) Clean air pump or cylinder of ultra pure air and a pressure regulator
    b) Filtration system
    c) Canister of span gas (SUVA –134a Refrigerant)
    d) Flow rate measuring device
    e) Tubing (must be compatible with gases utilized)
2) Variables and Terminology
    e) b_{scat} = σ_{sp} = bs = extinction coefficient for light scattering

(1) Rayleigh coefficient = light scattering due to particle-free atmospheric gases (altitude dependent)
    f) tc = Data average time constant in seconds
    g) den = average air density (manually set)
    h) zden = air density during zeroing
    i) zero = background suppression as a fraction of calibrator extinction coefficient
    j) gas = theoretical span gas coefficient
    k) span = ratio of internal calibrator to air Rayleigh coefficient
    l) wall = background noise of instrument
    m) local millibars = absolute ambient barometric pressure (mbars x 0.0295 = inches mercury [in Hg]).
    n) local Kelvin = local ambient temperature (^{o}C + 273.16 = K)

3) Procedure
    e) Document the time/date and the day of the week in the appropriate Nephelometer Site Logbook. Upon each site visit, the site operator shall initial the site logbook.
    f) Document the current weather conditions (visibility). Note exceptional visibility events observed during the prior week (e.g., smoke).
    g) Note any abnormalities with any of the following: instrument supports, nephelometer, calibration gas system, or datalogger. Clean the air system (check filter and replace if necessary).
    h) Starting at the first screen (“Radiance Research” displayed), toggle the **Display** - **Next** switch to display the b_{scat} instantaneous value. If applicable, compare this with the value measured by the external datalogger. Next,

check the nephelometer and datalogger clocks for accuracy. Note any discrepancies.

i) Toggle to “Temperature and Barometric Pressure” and then manually enter the shelter temperature and barometric pressure values when appropriate (current – for calibrations) by toggling the **Parameter-Raise/Lower** switch.

j) Toggle the **Display – Next** switch until “Cal Gas/Air Set” is displayed. Verify that the appropriate ratio is displayed (SUVA 134a = 7.35).
Note: The cal gas/air ratio is constant for temperature and pressure. The GAS value is computed automatically by the nephelometer when the current temperature and barometric pressure values are input. The calculation is based upon:

$$GAS = \sigma_{sp}(T = 0^{o}C)\left[\frac{T_{std}}{T_{amb}} \times \frac{p_{amb}}{p_{std}}\right]$$

where,

$$\sigma_{sp}(T = 0^{o}C)_{SUVA\,134a} = 14.2 \times 10^{-5}\, m^{-1}$$

k) Toggle the **Display – Next** switch until the “Zero” screen is displayed.

l) If applicable, disable the datalogger channel for the nephelometer.

m) Turn off the exhaust fan and restrict the outlet with tape.

n) Remove the probe line and connect the clean air source to the inlet of the nephelometer. Introduce 2.0 to 20.0 liters per minute (lpm) of clean air.

o) Switch to fast mode. Wait for approximately five minutes or until a stable reading is obtained. Record the final zero value.

p) Adjust the zero setting if b_{scat} > ±0.05e-5; otherwise, continue with step m. To perform the zero adjustment, wait for a steady value. Once a steady value is obtained, toggle the **Item** switch up (fast response) or down (slower response) while toggling the **Parameter** switch to the proper direction until the b_{sca} value is within the correct range.

q) Depress **Display – Next** once so that the Span screen is displayed.

r) Connect the span gas source to the inlet of the nephelometer. Begin with approximately 2.0 to 20.0 lpm of the span gas.

s) While still in fast mode, wait for approximately five minutes or until a stable reading is obtained. Record the final span value.

t) Using the following equation, compare the b_{scat} to the gas number obtained during the span.

$$\%\ Diff = 100 \times \left(\frac{b_{scat} - Gas}{Gas}\right)$$

u) Adjust the nephelometer span if the percent difference (% Diff) is more than ±10% or is out of control limits.

v) After adjustments to the nephelometer have been completed, perform steps f-p once more, without analyzer adjustment, to ensure proper zero and span settings. Record these values as the final readings. Note: adjustments to the zero can affect the span setting and adjustments to the span can affect the zero constant.

w) Remove the zero/span connector from the inlet. Remove the outlet restrictor. Reconnect all original connections and power up the exhaust fan.

x) If applicable, enable the datalogger channel(s).

J.3 DATA COLLECTION, REDUCTION AND VALIDATION

The Radiance Research nephelometer output data will be measured and collected by a datalogger. The datalogger will record one-hour averages, which will be collected via telephone modem by the Idaho Department of Environmental Quality (DEQ) data acquisition system. The data will then be processed into monthly data reports.

1) The site operator shall review the monthly data reports and flag data associated with calibration, maintenance, and audit activities.
2) The site operator shall flag data associated with rate of changes exceeding 0.05 per kilometer $(km)^{-1}$
3) The site operator shall flag over-range and under-range ($<0.00\ km^{-1}$) data for review.

J.4 DATA REPORTING AND ARCHIVING

J.4.1 Data Reporting

1) Data validated monthly by regional offices will be sent to the DEQ State Office for reporting.
2) The DEQ State Office will review and validate the monthly reports upon receipt from the field offices. The flagged data will be identified with the appropriate "null codes" prior to submittal to the Air Quality System (AQS) database.
3) Data will be submitted to AQS database within 90 days of the proceeding quarter.

J.4.2 Data Archiving

All nephelometer data will be archived in the AQS database.

J.5 PREVENTIVE MAINTENANCE

1) Switch the nephelometer's power off. Disconnect the inlet tube. Remove the four screws from the dark trap (top section) with an appropriately sized Allen wrench.
2) To remove the dark trap, insert a sharp edge or tap off.
3) Check the condition of the O-ring.
4) File any burrs detected on the flanges of the dark trap or optical tube.
5) Using low pressure compressed gas, blow out any accumulated particles (dust, bugs, spider webs, etc.) from the optical tube and dark trap.
6) Clean the mirror if necessary.
7) Check the aperture ring for debris; clean if necessary.
8) Check for water (stains and/or standing).
9) Check the interior for black paint loss (peeling). If necessary, paint the interior with a flat black paint.
10) Reassemble the unit. Ensure that the baffle is aligned with the lamp.
11) Switch the unit's power on and observe, through the inlet, that the lamp is flashing. **Warning**: Only look at the lamp for brief periods. The UV light can burn your eye if you stare at the lamp.
12) Clean the inlet tube with compressed air and then reconnect to the nephelometer.
13) If necessary, clean or replace the air filter.

J.6 TROUBLESHOOTING

J.6.1 Unit Not Operational

1) Check the flash lamp.
2) Check the power cord assembly for broken plugs, frayed insulation, or other signs of damage. A continuity check may be necessary to verify that the power cord is operational.
3) Check the fuse box or the main breaker panel.
4) Check the 12 volt, direct current (DC) transformer for proper output voltages. A digital multimeter will be required to accomplish this task.

J.6.2 Nephelometer Data are Consistently High or Low

1) If the wall scatter is greater than 75% then water or other material may have contaminated the optical tube and cleaning will be necessary. If cleaning doesn't improve the wall scatter percent, the optical alignment may need to be adjusted.
2) Light may have entered the optical tube. Check the O-ring at the dark trap and the gasket at the lamp.
3) The internal span chopper may be malfunctioning. Check the chopper operation.

J.7 AUDITING THE NEPHELOMETER

A nephelometer performance audit verifies the accuracy of the instrument calibrations. The audit assesses the data for accuracy and ensures the data integrity. Audit the nephelometer at least once per year.

J.7.1 Audit Procedure

Follow the general procedure below for the audit.

1) Perform a pre-audit zero and span check with the station calibration system.
2) Perform the audit zero and span check with an independent source of clean air and span gas.
3) Compare the audit calibration results with the station calibration results.
4) Document the results in the log book, or on a field annotated audit form.

J.7.1.1 Pre-Audit Verification

1) Have the site operator perform a weekly zero and span check (Section J.2.2.1) using the station calibration equipment.
2) Record the results in the site logbook and on the Audit Results Worksheet.

J.7.1.2 Performance Audit

1) Replace the station zero air filter assembly with the independent audit equipment. Replace the station span gas assembly with the independent audit equipment. The equipment should contain the following:

e) Clean air pump or cylinder of ultra pure air and a pressure regulator
f) Filtration system
g) Canister of span gas (SUVA –134a Refrigerant)
h) Flow rate measuring device
i) Tubing (must be compatible with gases utilized)

2) Perform an audit span check following a procedure similar to a monthly zero and span check, utilizing the following steps:
   a) In the nephelometer's first screen ("Radiance Research" displayed), toggle the **Display – Next** switch to display the b_{scat} instantaneous value.
   b) Turn off the exhaust fan and restrict the outlet with tape.
   c) Connect the span gas source to inlet of the nephelometer. Begin with approximately 2.0 to 20.0 lpm of span gas.
   d) Toggle the **Reset – Average** switch. Wait for a stable reading. Record the final value.
   e) Shut off the span gas and connect the clean air source to the inlet.
   f) Run clean air gas at 2.0 to 20.0 lpm. Toggle the **Reset – Average** switch.
   g) Wait for a stable value. Record the final value.
   h) Shut off the clean air gas and remove the zero/span connector from the inlet. Remove the outlet restrictor. Reconnect all original connections and power up the exhaust fan.
3) Record the results on the Audit Results Worksheet and in the site logbook.

J.7.1.3 Results Comparison

1) Compare the results of the zero/span check to the results of the performance audit zero/span values and record on the Audit Results Worksheet. This data will be used to determine the total amount of system drift.
2) Use the following equation to calculate the percent differences for the zero/span (station and complete) measurements:

The nephelometer is operating correctly when the percent difference (% Diff) is

$$\%\ Diff = 100 \times \frac{Station(or\ Complete) - Audit}{Audit}$$

   a) less than 15%, and
   b) the zero is ±0.05 E-5 (±5 E-5%).

J.7.1.4 Equipment

The auditor should now do the following:

1) Ensure the time and date of the datalogger and nephelometer are in agreement to within ±15 minutes.
2) Ensure the nephelometer-displayed readings are within ±5% of the readings recorded on the datalogger.
3) Note any inconsistencies with the siting or physical condition of the site.

J.7.1.5 Audit Report

The audit report should contain the following components:

1) A general description of the site and pertinent equipment.
2) A description of the audit methodology.
3) The audit zero/span comparisons and the Audit Result Worksheet.
4) Noted inconsistencies.
5) Recommendations for the site.

APPENDIX K: MULTI-GAS CALIBRATION SYSTEMS

STATE OF IDAHO

DEPARTMENT OF ENVIRONMENTAL QUALITY

AIR MONITORING QUALITY ASSURANCE

STANDARD OPERATING PROCEDURES

FOR

AIR QUALITY MONITORING

THERMO ELECTRON MODEL 146C DYNAMIC GAS CALIBRATOR

AND TELEDYNE API SERIES 700 MASS FLOW MULTI-GAS CALIBRATOR

MONITORING, MODELING, AND EMISSIONS INVENTORY

OCTOBER 2002

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TECO MODEL 146C & API SERIES 700 CALIBRATORS

FIGURES

TABLES

TECO Model 146C and API Series 700 Calibrators

Acronyms, Units, And Chemical Nomenclature

API	Advanced Pollution Instrumentation
CPU	Central Processor Unit
DAC	Digital-to-Analog converters
DC	Direct Current
DEQ	Department of Environmental Quality
ESD	electrostatic discharge
FEP	perfluoro (ethylene-propylene) copolymer
IBL	Idaho Bureau of Laboratories
kHz	kilohertz
LED	Light-Emitting Diodes
MFC	Mass Flow Controllers
nm	Nanometer (10^{-9} meter)
NIST	National Institute of Standards and Technology
NO	Nitrogen Oxide
O_3	Ozone
PCA	Printed Circuit Assembly
PFA	Perfluoroalkoxy
psig	Pounds per Square Inch, Gage
PTFE	Polytetrafluoroethylene
PVDF	Polyvinylidene Fluoride
sccm	Standard Cubic Centimeter per Minute
slpm	Standard Liters per Minute
SOP	Standard Operating Procedure
TECO	Thermo Electron Corporation
UV	Ultraviolet light
VAC	Volts Alternating Current
VDC	Volts Direct Current

REFERENCES

TECO MODEL 146C AND API SERIES 700

MASS FLOW MULTI-GAS CALIBRATORS

This standard operating procedure (SOP) references two different manufacturer's instruction manuals for mass flow multi-gas dilution calibration systems. One of the models is a Thermo Electron Corporation (TECO) Model 146C Multigas Calibration System. This SOP references the February 2000 instruction manual for the TECO Model 146C. The other model is the Advanced Pollution Instrumentation (API) Series 700 Mass Flow Multi-Gas Calibrator. This SOP references the July 1995 instruction manual for the API Series 700. This document combines each of these model's instruction manuals into a general SOP. Where differences exist between the calibrators, the specific model will be referenced and the manufacturer's instruction manual referred to.

K.1 GENERAL INFORMATION

Below are brief introductions into the theory of operation and any necessary operational, and maintenance precautions.

K.1.1 Theory Of Operation

These calibration systems provide precise concentrations of specific gases utilizing any of four possible methodologies. These methodologies are:

1. Precision Gas Dilution,
2. Transfer Standard Ozone Generating Source,
3. Permeation Tube Oven, and
4. Gas Phase Titration.

In each case, a supply of "zero" air is required to dilute the high concentration gases in order to attain the necessary concentrations. Zero air refers to the purity of the diluent gas, indicating a non-detectable concentration of the pollutant under investigation. A zero air source must be available and attached to the appropriate inlet port on the back of the calibrator system. See Figure K.1.1 for a generic flow and control schematic diagram.

K.1.1.1 Precision gas dilution employs central processor unit (CPU)-controlled precision mass flow controllers (MFC). National Institute of Standards and Technology (NIST) certified gas cylinders, each containing a pollutant gas in an inert (nitrogen) carrier, provide precise gas concentrations through a precision, low flow MFC. Concurrently, relatively high flow rates of diluent zero air are supplied by a second precision MFC. Each MFC provides an electrical signal to the CPU. The CPU calculates the necessary flows to attain the desired pollutant concentration. The equation necessary to calculate the required zero air and pollutant gas flows is:

$$C_f = C_i * \left(\frac{Q_{gas}}{Q_{gas} + Q_{air}} \right)$$

Where: C_f = final concentration of the diluted gas

C_i = source gas concentration

Q_{gas} = volumetric flow rate of the source gas

Q_{air} = volumetric flow rate of the zero air source

The MFC used to control the diluent air has a higher volume capability (approximately 1 standard liter per minute [slpm]) than the MFC used to control the source gas (approximately 10 standard cubic centimeters per minute [sccm], or 0.01 slpm). This allows the control system to develop various gas concentrations, ranging from trace amounts up to high concentrations, limited only by the concentrations available from the NIST traceable gas source. The low flow gas and the high flow diluent are mixed in an inert (Teflon®) chamber prior entering the exhaust manifold where the analyzers to be calibrated pull their samples from.

K.1.1.2 Both of the calibrators can generate ozone (O_3). The equipment contain both an internal O_3 generator and an O_3 photometer. Ozone is generated by exposing the zero air to 185 nanometer light. Light at this wavelength is in the ultraviolet (UV) region of the electromagnetic spectrum. The O_3 concentration is regulated by varying the UV lamp intensity inside the O_3 generator utilizing a feedback loop from the photometer. Diluting the output from the O_3 generator with zero air can provide additional flexibility for varying the concentrations of calibration O_3.

K.1.1.3 A permeation oven can also be installed in these calibration systems. A permeation device is designed to deliver precise concentrations of the contained gas when the permeation tube is maintained at a constant temperature. Zero air is used to entrain the effused gas and deliver a precision concentration of calibration gas. This gas stream can be diluted further to obtain the desired concentrations. Permeation ovens are most effective in supplying gases that can be liquefied at atmospheric temperature and pressure, such as sulfur dioxide and nitrogen dioxide.

K.1.1.4 Gas phase titration can be accomplished when an O_3 generator is present in the calibrator's configuration, coupled with a precise source of nitrogen oxide (NO). Usually, the source of a precise concentration of NO is a NIST traceable, certified gas cylinder. Gas phase titration is performed by mixing a regulated amount of NO with O_3, allowing the species to react in a supplied reaction chamber for a prescribed length of time. The reaction that occurs is:

$$NO + O_3 \Rightarrow NO_2 + O_2 + h\upsilon$$

The output from the reaction chamber is evaluated by a nitrogen oxide analyzer. The difference between the NIST traceable NO concentration and the nitrogen oxide analyzer's reported NO concentration is taken to be the concentration of nitrogen dioxide supplied for analysis.

K.1.2 Cautions

1. Light from the O_3 generator's ultraviolet lamp can burn the eyes. Use protective glasses to view the lamp or look at it only for a few seconds at distances of two or more feet. Do not touch the lamp face.

2. The calibrator contains a high voltage direct current (VDC) power supply for the UV lamp, a 24 VDC switching power supply to operate direct current (DC) operated valves, and 115 volt alternating current (VAC) at the input terminals. When working on this equipment use all high voltage precautions.

3. The calibrator contains both high voltage power supplies and delicate electronics. Use a third wire ground on this equipment to properly ground conducted and emitted transmissions.

4. Electrostatic discharge (ESD) can damage sensitive electronic printed circuits. To limit damage due to ESD, properly ground all work surfaces, and technicians prior to working on this equipment.

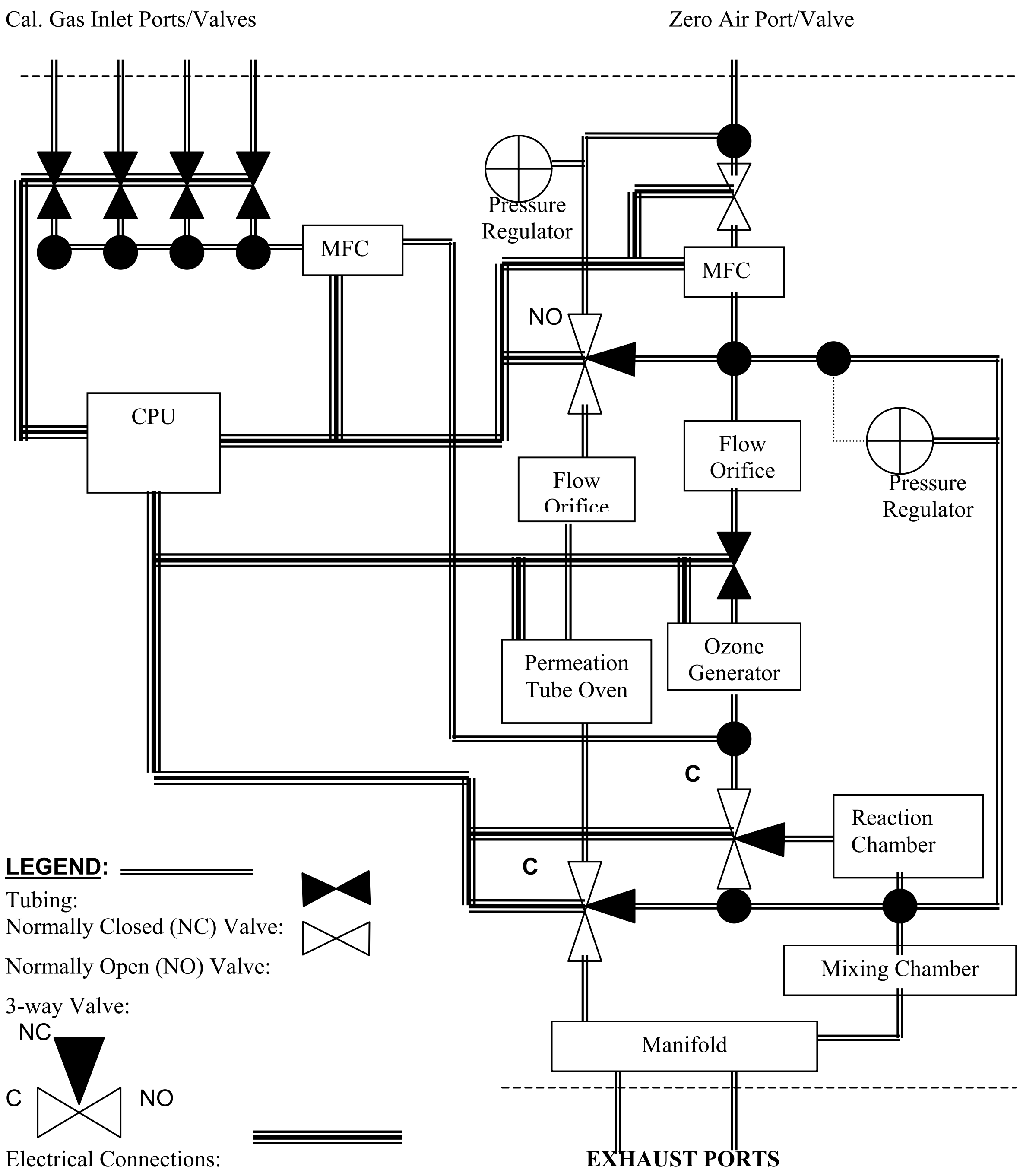
5. Improper handling can damage printed circuit boards. Do not touch components on the surface of the boards, or touch the connector leads, or contact surfaces. Oils from human contact will corrode the contacts. Handle by the edges alone.

6. Buildup of excessive concentrations of gas in the permeation tube oven can yield inaccurate concentrations. To prevent this, keep a constant supply of zero air flowing through the permeation tube.

7. Improperly restrained pumps, permeation tube ovens, analyzer benches, and other internal equipment will impair the correct operation of the calibrator. Remove all bench securing screws and tie-down straps prior to applying power.

8. Calibrators can be damaged by too much pressure. Reduce the inlet pressure below 8 pounds per square inch, gauge (psig) prior to capping the outlet during leak and pressure checks.

Functional Diagram



K.2 ROUTINE SERVICE CHECKS

Verify the functionality of the calibrator periodically according to the calibrator service schedule provide in Table K.2.1. Utilize the Quality Control Maintenance Check Sheet provided in Figure K.2.1 to track the months in which the service activity was performed.

Table K.2.1
TECO Model 146C and API Series 700 Calibrator Service Schedule

ACTIVITY	Quarterly	Semi-Annually	Annually
GENERAL BENCH INSPECTION AND REPAIR OPERATIONS			
Inspect Bench Tubing for Contamination and Damage	X		
Leak Check Bench	X		
Verify Solenoid Valve Function	X		
Replace Inlet Particulate Filter		X	
Inspect Cooling Fan			X
Clean or Replace Cooling Fan's Filter			X
Inspect/Replace O-Rings			X
Clean Flow Restricting Devices			X
Inspect/Adjust Pressure Regulator			X
Calibrate Bench			X
Replace Sample Pump	As Required		
Replace Inlet and Outlet Fittings	As Required		
OZONE GENERATOR/TRANSFER STANDARD			
Verify Lamp Intensity		X	
Inspect/Replace O_3 Generator Heater	As Required		
Inspect/Replace UV Lam	As Required		
Verify proper O_3 Generator Power Supply output range	As Required		
PERMEATION TUBE			
Verify Permeation Tube Contents		X	
Inspect Permeation Oven			X
MASS FLOW CONTROLLERS			
Verify MFC Output			X
ELECTRONICS/INTERCONNECT/POWER SUPPLIES			
Verify Wire Integrity/Strain Relief Function			X
Inspect Connector Pins/Bodies for bent pins or cracked cases	As Required		
Verify Connectors are Fully Inserted	As Required		
Verify PCAs are Fully Inserted	As Required		
Verify Ozone Transfer Standard Power Supply per Specifications			X

QUALITY CONTROL MAINTENANCE CHECK SHEET
TECO MODEL 146 & API SERIES 700 CALIBRATION SYSTEMS

Technician:__________ Calibrator Property Number:__________ Year:__________

ACTIVITY	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	SCHEDULE
Inspect Bench Tubing													Quarterly
Leak Check Bench													Quarterly
System Vacuum Check													Quarterly
System Flow Check													Quarterly
Verify Solenoid Valve Function													Quarterly
Replace Inlet Particulate Filter													Semi-Ann
Inspect Solenoid Valve Seats													Semi-Ann
Inspect Tubing for Dirt													Semi-Ann
Inspect Cooling Fan													Annually
Replace Cooling Fan's Filter													Annually
Inspect O-Rings													Annually
Clean Orifices													Annually
Inspect Pressure Regulators													Annually
Calibrate Bench													Annually
Replace Sample Pump													As Req'd
Replace Inlet & Outlet Fittings													As Req'd
Verify Ozone Lamp Intensity													Quarterly
Replace Ozone UV Lamp													As Req'd
Verify Permeation Tube Contents													Quarterly
Inspect Permeation Tube Heater(s)													Semi-Ann
Verify MFC Output against BIOS													Annually
Verify Wire Integrity/Strain Relief													Annually
Inspect Connector Pins / Bodies													As Req'd
Verify Connectors Fully Inserted													As Req'd
Verify PCAs are Fully Inserted													As Req'd
Verify O_3 Power Supply per Spec.													Annually

Figure K.2.1 Quality Control Maintenance Check SheetK.3 MAINTENANCE PROCEDURES

NOTE: Cautions listed in Section K.1.2 should be noted while performing troubleshooting or maintenance on the analyzer. Additionally, troubleshooting or repairs must not be performed on any electronics without properly worn and grounded ESD grounding straps.

K.3 MAINTENANCE PROCEDURES

K.3.1 Tubing

Inspect tubing periodically in accordance with the schedule provided in Table K.2.1. Damage may consist of, but is not limited to, constrictions, kinks, cuts, nicks, collapsed sections, or visible signs of contamination lining the interior surfaces. Visible signs of contamination may include, but not be limited to, clouding, discoloration, and pitting of the tubing inner surface, cracking, hardening, or any signs of brittleness of the tube, and any change in diameter. Replace all sections that are damaged.

K.3.2 Leak Checks

Perform leak checks per the calibrator's instruction manual. For the TECO Model 146C, perform leak checks as directed in "Leak Checking" on page 7-4 of the manual. For the API Series 700, perform leak checks as directed in "Leak Check Procedure" in the instruction manual.

K.3.3 Solenoid Valves

Energize each solenoid valve to verify that it works properly. Any indication that the solenoid valve does not open, or does not close completely, must be investigated further. A rotameter, or other flow-measuring device, can be used to verify that the valve opens and closes completely. Any flow measurable after the solenoid valve is de-energized, for normally closed valves, or energized, for normally open valves, indicates that the solenoid valve must be replaced. Refer to the calibrator's instruction manual for removal and repair procedures.

K.3.4 Inlet Particulate Filters

Inspect and replace any particulate filters that are dirty. Follow the procedures identified in the calibrator's instruction manual.

K.3.5 Cooling Fan and Filter

Inspect the cooling fan to insure that it rotates freely. Remove the filter and clean the fan blades if they appear dirty. Clean the filter with soap and water if it is a resilient material; otherwise, replace the filter. Clean fan filters are necessary to ensure sufficient cooling airflow through the calibrator. Follow the procedures identified in the calibrator's instruction manual.

K.3.6 O-Rings

Inspect and replace any O-ring seals that exhibit surface cracking, discoloration, brittleness, or any other characteristic that indicates the material has degraded due to chemical exposure.

K.3.7 Flow Restricting Devices

Inspect, clean, and/or replace any flow restriction devices. Flow restricting devices usually consist of critical orifices or capillary tubes. Other restricting configurations are possible. Verify that the device is clean and operating properly. Follow the procedures identified in the calibrator's instruction manual for disassembly, inspection, cleaning, and replacement.

K.3.8 Pressure Regulator Inspection/Adjustment

Inspect the pressure regulators for proper operation. Any indication that the pressure regulators are not operating properly must be addressed immediately. Adjust the pressure regulator as indicated in the calibrator's instruction manual. TECO Model 146C instructions are located on page 7-5.

K.3.9 Calibration Bench

Calibrate the calibration system according to the schedule provided in Table K.2.1. Follow the instructions in the calibrator's instruction manual.

K.3.10 Sample Pump

On those systems provided with sample pumps, inspection, repair, and possibly replacement are needed periodically. Be aware of the pump's operation while performing leak checks and flow inspections. Any indication of substandard pressures, vacuums, or flows may indicate that the pump needs to be refurbished or replaced. Refer to the calibrator's instruction manual for proper removal, repair, and replacement procedures.

K.3.11 Fittings

Repeated use of fittings can damage the threads and forcing cones. Any chips, dents, cracks or other non-standard configuration to the fitting indicates that the fitting has been damaged and must be replaced to ensure a proper seal is provided. Replace fittings with acceptable materials only. Acceptable materials include, but may not be limited to, stainless steel, Teflon® (PTFE or FEP), or Kynar® (polyvinylidene fluoride [PVDF]).

K.3.12 Ozone Generator Heater

Periodically inspect the operation of the ozone generator heater. Replace, following the instructions in the calibrator's instruction manual, if an insufficient or fluctuating module temperature is observed.

K.3.13 Ultraviolet Lamp

Periodically inspect the operation of the ozone generator. Replace, following the instructions in the calibrator's instruction manual, if insufficient or fluctuating O_3 concentrations are observed.

K.3.14 Ozone Generator Power Supply

Periodically inspect the operation of the O_3 generator. Replace, following the instructions in the calibrator's instruction manual, if insufficient or fluctuating O_3 concentrations are observed.

K.3.15 Permeation Tube

Inspect the operation of the permeation tube semi-annually. Replace the permeation tube, following the instructions in the calibrator's instruction manual, if insufficient or fluctuating concentrations are observed.

K.3.16 Permeation Oven

Annually inspect the operation of the permeation oven. Replace the permeation tube heater, following the instructions in the calibrator's instruction manual, if insufficient or fluctuating concentrations are observed.

K.3.17 Mass Flow Controllers

Annually inspect the operation of the MFCs. Replace, repair, or calibrate the MFCs, following the instructions in the calibrator's instruction manual or the Idaho Bureau of Laboratories' (IBL) MFC calibration procedure, if inaccurate or fluctuating flow rates are observed.

K.3.18 Interconnect (Wiring Harness)

NOTE: Prior to touching any electrical/electronic components, verify that the power is shut off, power cord disconnected, work surface properly grounded, and that the technician is wearing a properly grounded wrist strap to limit potential ESD damage.

Inspect the electrical interconnect (wiring harness) for damage due to chemicals or physical abuse annually. Physical abuse includes being exposed to excessive heat, cutting the insulation, smashing or crimping the wires when the covers are closed, or installing equipment . Damage may exhibit itself as discolored, missing, or smashed/displaced insulation.

Additionally, connectors may be disconnected, or damaged inadvertently during maintenance, repair, and calibration operations. Carefully inspect the connectors for damage to their bodies, such as cracked and chipped surfaces. Verify that all connectors are securely seated into their mating connector. While the connector is disconnected, visually inspect the face for missing and/or bent pins. Finally, annually verify that the strain relief securely retains the wire bundle where it enters the connector. Any damage identified should be assessed, and if deemed necessary, repaired immediately. Consult the operations manual for proper repair procedures.

K.3.19 Electronics

NOTE: Prior to touching any electrical/electronic components, verify that the power is shut off, power cord disconnected, work surface properly grounded, and that the technician has a properly grounded wrist strap on to limit potential ESD damage.

Individual printed circuit assemblies (PCA) must be periodically detached and inspected. The PCAs to inspect include, but may not be limited to:

- Processor PCA
- Analog to Digital PCA
- Digital to Analog PCA
- Input/Output PCA
- DC Power Supply PCA
- Ozonator PCA
- Permeation Oven Temperature Control PCA
- Mother (Back Plane) PCA

The electronics attached to the PCAs must be inspected for discolored components, darkened areas, and disconnected components. Each of these signs indicates a major electrical discharge incident, and the effected PCA(s) must be replaced. Additionally, the entire instrument must be thoroughly inspected for any collateral damage to the interconnect (wiring harness), sensors, displays, keypads, and other electrical components. Follow the calibrator's instruction manual for repair and replacement procedures.

Dust off the PCA and reinsert into the mating connector. Removing the dust will help the electronics operate at a lower temperature and will reduce the likelihood of arcing damage to adjacent components. Be careful not to damage components or the connector pins during cleaning and reinsertion.

K.3.20 Power Supplies

NOTE: Prior to touching any electrical/electronic components, verify that the power is shut off, power cord disconnected, work surface properly grounded, and that the technician has a properly grounded wrist strap on to limit potential ESD damage.

Clean any accumulated dust, lint, and other foreign matter from the surface of the power supplies and any associated PCAs. Inspect for any apparent ESD damage. Replace the power supply if the outputs do not meet the specifications provided in the calibrator's instruction manual. Reinstall as indicated in the calibrator's instruction manual.

Table K.1.2.1 provides descriptions for the modules located in the various power supplies.

Table K.3.1
Power Supply Module Subassemblies

MODULE	DESCRIPTION
Linear Power Supply PCA[a]	The linear power supply PCA takes multiple voltage inputs from the power transformer and produces +5, +12, ±15, and 24 VDC[b] outputs. The outputs are routed to two external connectors. The +5 VDC is used for operating the CPU. The ±15 VDC is used in several locations for running op-amps and ICs. The +12 VDC is used for operating the fans and valves.
Switching Power Supply	The switching power supply provides +24 VDC at 4 amps to the UV[c] lamp power supply module. There is a load resistor on the switch PCA to keep the output stable when little current is required from the supply.
Switch PCA	The switch PCA has many different functions. It takes logic signals from the V/F[d] PCA and uses them to switch 4-115 VAC[e] and 4-12 VDC loads. The PCA also contains the instrument central grounding tie point. It routes un-switched AC and DC power as needed. This PCA provides access to program the power transformers to accept 115, 220, or 240 VAC inputs.
Power Transformers	There are potentially two input power transformers in the instrument. The multi-tap transformer is in every API Series 700 and supplies input power for the linear power supply PCA. A second transformer is added if 220 or 240 VAC input is required. Input power selection is done via a programming connector that provides the proper connections for either foreign or domestic power.
Circuit Breaker/Power Switch	The front panel contains a combination circuit breaker/input power switch, which is connected to the power supply module. If an overload is detected the switch goes to the OFF position. Switching the power back on resets the breaker.

[a] Printed Circuit Assembly
[b] Volts, Direct Current
[c] Ultraviolet
[d] Voltage/Frequency
[e] Volts, Alternating Current

K.4 TROUBLESHOOTING

K.4.1 General Information

NOTE: Cautions listed in Section K.1.2 should be observed while performing troubleshooting or maintenance on the analyzer. Additionally, troubleshooting or repairs must not be performed on any electronics without properly worn and grounded ESD grounding straps.

As with all electrical/electronic equipment, the DC power supplies are the first items that should be checked when a problem occurs. The following instructions assume that the DC power supplies have been checked and eliminated as the potential problem.

If status light emitting diodes (LEDs) are present, a lit or flashing red LED may indicate a warning condition exists and requires attention. See the calibrator's instruction manual for use of LEDs, warning lights, or other forms of warning notification.

K.4.2 Troubleshooting Guide

Periodically, calibrator operation will be problematic. In such situations, refer to Table K.4.1 for guidance in identifying and rectifying the situation.

Table K.4.1
TECO Model 146C Troubleshooting Check List

MALFUNCTION	POSSIBLE CAUSE	ACTION
Flow Controller Unstable	1. Gas or zero air source not adequate or pressure too low. 2. Flow controller malfunction. 3. Leak.	1. Increase pressure (to greater than 25 psig), and/or flow from gas, and/or zero air source. 2. Refer to flow controller manual in calibrator's instruction manual. 3. Execute a leak check as indicated in the calibrator's instruction manual.
Solenoid not switching in local mode	1. Instrument in remote mode. 2. Solenoid malfunction. 3. Solenoid driver malfunction.	1. Put instrument in local mode 2. Check solenoid for continuity and replace as necessary. 3. Check power supply.
Solenoid not switching in remote mode.	1. Instrument in local mode. 2. Input/output PCA failure. 3. Bad connectors.	1. Put instrument in remote mode. 2. Replace appropriate PCA. 3. Replace connectors.
Calibration as measured at output of MFC does not agree with calibration as measured at output of instrument.	1. Leak.	1. Perform leak check.
No O_3 output.	1. Lamp failure. 2. Ozonator heater failure. 3. Ozonator power supply failure.	1. Check for blue light when removing O_3 lamp from ozonator and replace lamp if light is not visible. 2. Check to see that ozonator is warm (≈50 °C). If not, replace or repair heater or heat power supply. 3. Repair or replace ozonator power supply.
Low O_3 output.	1. Leak in ozonator or distribution manifold. 2. Flow excessively high. 3. Power supply failure. 4. Weak lamp.	1. Check for leaks in ozonator or manifold system and repair leak. 2. Check zero airflow valve and adjust to less than 8 slpm. 3.Voltage on primary of step-up transformer with ozonator level set to 100% should be greater than 16 volts. If not, repair or replace ozonator power supply. 4. Check to see that there is a bright blue light when removing the ozone lamp. If not, replace lamp.
Unstable O_3 output.	1. Failure of analyzer measuring O_3. 2. Leak in system. 3. Zero airflow unstable. 4. Lamp failure. 5. Defective O_3 power supply.	1. Repair analyzer. 2. Check for leaks and repair. 3. Check zero airflow meter. 4. Replace with new lamp. 5. Verify lamp power supply is providing a 15 kHz square wave. If not, repair or replace power supply.

MALFUNCTION	POSSIBLE CAUSE	ACTION
Permeation oven fails to warm up.	1. Not enough time has elapsed since turning oven on. 2. Oven heater circuit is shorted or open. 3. Heater voltage not present or improperly calibrated. 4. Control circuit malfunction. 5. Set point not set properly.	1. Wait one hour from powering up instrument. 2. Replace oven. 3. Follow adjustment procedures outlined in calibrator's instruction manual. 4. Replace permeation oven PCA. 5. Check for correct resistors. Refer to calibrator's instruction manual for the correct resistor to set the oven temperatures.
Temperature display erratic.	1. Flow through permeation tube oven is not constant.	1. Clean flow restricting device and critical orifice or capillary; readjust regulator as indicated in the calibrator's instruction manual.

Table K.4.2
API Series 700 Front Panel Warning Messages

MESSAGE	DESCRIPTION
SYSTEM RESET	System was powered on or reset. This warming occurs every time the instrument is powered up, as in after a power failure. It can also occur if the RAM[a] or EEPROM[b] is reset.
RAM INITIALIZED	RAM was erased and re-initialized. The RAM contains temporary data used by the Series 700. No setup variables are stored in the RAM.
CAL[c] GAS PRESSURE WARNING	Calibration gas pressure is above 30 psig[d] or below 25 psig. If the gas pressure is above 33 psig or below 15 psig, the CPU will shut off the valve system for safety.
DILUENT PRESSURE WARNING	Diluent air pressure above 30 psig or below 25 psig. If the gas pressure is above 33 psig or below 15 psig, the CPU will shut off the valve system for safety.
REGULATOR PRESSURE WARNING	Regulator pressure is below 15 psig or above 25 psig.
CAL GAS/DILUENT FLOW WARNING	Calibration gas or diluent air rate through each corresponding mass flow controller is less than 10% of full scale.
V/F[e] CARD NOT INSTALLED	V/F card was not detected on power up. This probably means either: 1. the PCA[f] is not seated in the mating connector or 2. the PCA is defective.
PHOTOMETER LAMP TEMPERATURE WARNING (option)	Photometer lamp temperature is below 51 °C or above 61 °C.
O_3 GENERATOR LAMP TEMPERATURE WARNING (option)	O_3 generator temperature is below 43 °C or above 53 °C.
PHOTO REFERENCE WARNING (option)	Photometer reference reading is below 2,500 mV[g].
O_3 GENERATOR REFERENCE WARNING (option)	O_3 generator reference reading is below 50 mV. This warning is set only during reference feedback mode.
PERM[h] TUBE TEMPERATURE WARNING (option)	The permeation tube temperature is below 49 °C or above 51 °C.

[a] Random Access Memory
[b] Electronically Erasable / Programmable Read Only Memory
[c] Calibration
[d] pounds per square inch gauge
[e] Voltage/Frequency
[f] Printed Circuit Assembly
[g] millivolts
[h] permeation

Table K.4.3
API Series 700 Diagnostic Modes Summary

MESSAGE	DESCRIPTION
SIGNAL I/O[a]	Gives access to the digital and analog inputs and outputs on the V/F[b] PCA[c]. The status or value of all of the signals can be seen. Some of the signals can be controlled from the keyboard. NOTE – some signals can be toggled into states that indicate warnings or other faults. These settings will remain in effect until the DIAG[d] mode is exited. The Series 700 will then resume control over the signals.
ANALOG OUTPUT	Causes a test signal to be written to the analog output DAC[e] converters. The signal consists of a scrolling 0%, 20%, 40%, 60%, 80%, and 100% of the analog output value. The scrolling may be stopped by pressing the key underneath the "%" display to hold that value.
DAC CALIBRATION	The analog output is created by four DAC. Two (DAC 0 and DAC 1) are dedicated for MFC[f]. DAC 2 is for the O_3 generator control output, and DAC 3 is for the test channel output. This selection starts a procedure to calibrate these outputs. Refer to Section 9.1.4.1 of the API[g] Series 700 instruction manual for a detailed procedure.
TEST CHANNEL OUTPUT	Recorder output on the rear panel is used for the test channel output. See Section 9.1.3.1 and Figure 2.2 of the API Series 700 instruction manual for a detailed procedure.
AUTO LEAK CHECK	This diagnostic feature is part of an option with supporting hardware. It performs the automatic leak check. Refer to Section 8.2 of the API Series 700 instruction manual for a detailed procedure.
RS-232 OUTPUT	Causes a one-second burst of data to be transmitted from the RS-232 port. Used to diagnose RS-232 port problems. See Section 9.2.4 of the API Series 700 instruction manual for RS-232 port diagnostic techniques.

[a] Input / Output
[b] Voltage / Frequency
[c] Printed Circuit Assembly
[d] Diagnostic
[e] digital-to-analog
[f] Mass Flow Controller
[g] Advanced Pollution Instrumentation

K.5 ACCEPTANCE PROCEDURES

K.5.1 General Information

Before beginning acceptance testing of the calibrator, read the manual thoroughly. Then, initiate an instrument logbook and an Acceptance Test Mini-Report (Figure K.5.1).

K.5.2 Physical Inspections

Unpack the calibrator and check for physical damage. Remove the top cover from the calibrator and perform the following tasks:

NOTE: Prior to touching any electronics, properly ground yourself to the calibrator's housing to prevent ESD damage to the circuit cards.

1. Access the electronics; extract and reinsert the printed circuit boards.

2. Check for correct power cord phasing; standard wiring configuration has the black wire connected to the brass terminal of the plug, white to copper, and green to earth ground. Verify the analyzer chassis is grounded to earth ground.

3. Verify that the calibrator is complete upon receipt. (i.e., manuals, selected options, rack mount slides, etc. all present).

K.5.3 Operational Tests

Perform the following operational checks and record the results on the strip chart and mini report. Refer to the calibrator's instruction manual for specific directions to perform the following operational exercises.

1. Actuate all valves to verify functionality.

2. Test the pressure regulators for stable response over the input pressure range.

3. Verify that all meters (flow, pressure, temperature, etc.) accurately report the characteristic.

4. Verify that any pumps function within specification.

5. Actuate all switches, electromechanical and electronic, to verify that they are functioning properly.

6. Verify that MFCs are functioning properly:

    a. Verify that the low flow MFC module reports flows within tolerance of the calibration report.

    b. Verify that the high flow MFC module reports flows within tolerance of the calibration report.

7. Verify that the permeation tube oven heats the permeation tube to the specified temperature, within the reported tolerance range.

8. Verify that the UV lamp emits an intense blue light.

9. Verify that the O_3 generator heater heats the ozonator to the specified temperature, within the reported tolerance range.

10. Verify that the thermistors generate the appropriate resistance change for an applicable temperature range.

11. Verify that all indicator lamps are functional.

12. Verify that the O_3 generator provides an appropriate O_3 concentration.

13. Verify that the Permeation Tube provides the appropriate concentration.

14. Characterize the MFC:

    a. Characterize the low flow MFC according to the IBL characterization procedure.

    b. Characterize the high flow MFC according to the IBL characterization procedure.

TECO MODEL 146C & API SERIES 700 CALIBRATORS
ACCEPTANCE TEST "MINI REPORT"

Date of Review:___________________
Reviewed By:____________________
Serial No.______________________
Date of Acceptance_____________

I. Physical Inspection	Passed	Failed	Final OK
E. Checked for shipping damage	_____	_____	_______
F. Checked all electrical wiring	_____	_____	_______
G. Checked all Plumbing for leaks	_____	_____	_______
H. Analyzer complete upon receipt	_____	_____	_______

V. Operational Tests	Passed	Failed	Final OK
a) Checked operation of:			
i) Valves	_____	_____	_______
ii) Pressure Regulators	_____	_____	_______
iii) Meters	_____	_____	_______
iv) Pumps	_____	_____	_______
v) Switches	_____	_____	_______
vi) Mass Flow Controller (Low flow)	_____	_____	_______
vii) Mass Flow Controller (High flow)	_____	_____	_______
viii) Perm. Tube Oven	_____	_____	_______
ix) UV Lamp	_____	_____	_______
x) O_3 Generator Heater	_____	_____	_______
xi) Thermistors	_____	_____	_______
xii) Pressure Sensors	_____	_____	_______
xiii) Indicator(s) lamp(s)	_____	_____	_______

VI. Tests Performed (Attach Charts)	%FS Dev.	Range	Pass	Fail	Final OK
I. Verify O_3 Generator Concentration	_______	_____	___	___	_______
J. Verify Permeation Tube Concentration	_______	_____	___	___	_______
K. Characterize Low Flow MFC Range	_______	_____	___	___	_______
L. Characterize High Flow MFC Range	_______	_____	___	___	_______

VII. Special Tests: ____
____
____
____

V. Comments/Maintenance Performed: ____
____
____
____
____
____

Figure K.5.1 Acceptance Test Mini-Report

K.6 CHARACTERIZATION PROCEDURE

K.6.1 Introduction

The Department of Environmental Quality (DEQ) annually extracts the MFCs from the calibrators and sends them to be recertified. Recertification requires that the MFCs' output be compared to a primary flow standard for precision, bias, accuracy, and repeatability.

Additionally, DEQ characterizes each MFC upon its return. Characterization is done in order to increase the accuracy of the multi-gas calibration system. Characterization requires that the MFCs' output is recorded and compared to the output of a primary flow standard. No adjustments are made to the MFC. A minimum of five points are tested. The values are recorded and tabulated for future use. The characterization sequence may be performed multiple times to verify repeatability.

K.6.2 Apparatus

The following equipment and resources are required to characterize an MFC:

1. Gas cylinder - zero Air, free of contaminants (particulates, gases, etc.)

2. Primary flow standard

3. MFC

4. 30 psig pressure regulator

5. Control valve (needle)

6. One-quarter or one-eighth inch FEP or PFA Teflon® tubing for airflow connections

7. Necessary fittings: acceptable fitting materials include 316 stainless steel, FEP Teflon®, or Kynar® (PVDF)

Assemble the equipment as shown in Figure H.3.0.1.

K.6.3 Characterization Process

Characterizing the MFCs is critical in order to assure the accuracy of the diluted gas concentrations. The accuracy of mass flow controlled dilution is susceptible to atmospheric pressure variations. The controllers may not deliver the same mass flow in differing ambient environments. Consequently,

1. Set up the equipment according to the diagram provided in Figure K.6.1.

2. Select a minimum of five set points that will be used to characterize the MFC. If the MFC is a low flow unit (0 – 30 sccm), select the points, equally spaced between 10% full scale and 90% full scale (e.g., 10%, 30%, 50%, 70%, and 90% full scale). Select similar set points for the high flow MFC (0 – 10 slpm) (1.0 slpm = 1000 sccm).

3. Exercise the MFC according to the set points. Record the MFC response to each flow rate in the MFC Characterization Datasheet provided in Figure K.6.2..

4. Generate a graph that relates the true flow rate to the MFC reported flow rate by plotting the known mass flow against the MFC reported flow rate on the same graph.

    a. Plot the known mass flow on the abscissa (x-axis), and

    b. Plot the MFC's reported flow on the ordinate (y-axis).

5. Reinstall the MFC into the calibrator.

6. Insert a copy of the characterization curve in the calibrator's documentation/instruction manual and retain the original data set in the files.

NOTE: A perfectly calibrated MFC will yield a straight line issuing at a 45° angle from the origin of the graph. Any deviation from this 45° angle indicates that the MFC is not providing an accurate supply of gases. If the line makes an angle greater than 45° from the x-axis, the MFC is providing more gas than the calibration standard. Similarly, if the angle is less than 45° from the x-axis, the MFC is providing less gas than the calibration standard. Sever deviations from 45° indicate that the MFC should be replaced.

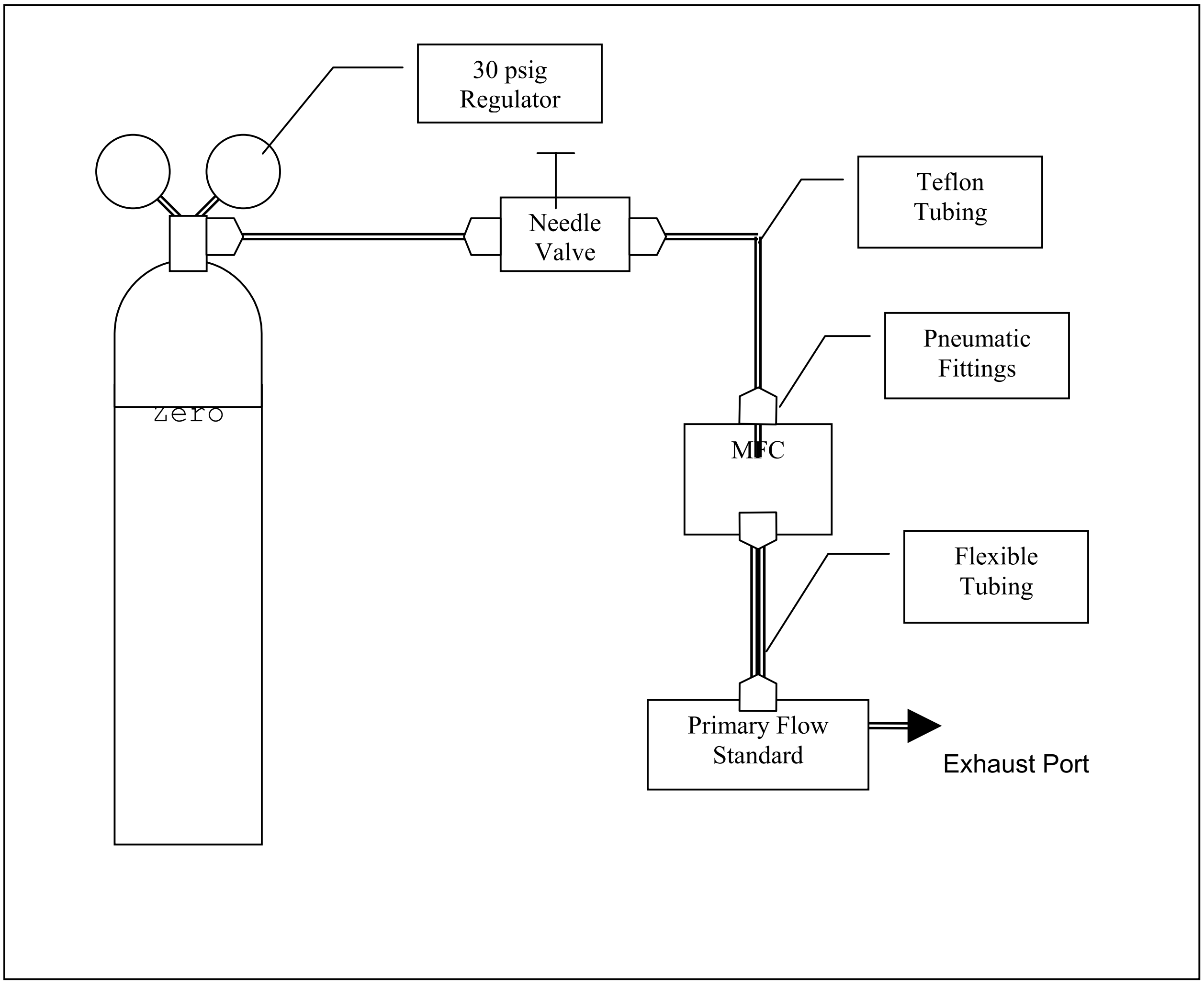


Figure K.6.1 Mass Flow Controllers Characterization Apparatus Diagram

IDAHO DEPARTMENT OF ENVIRONMENTAL QUALITY
MFC CHARACTERIZATION DATASHEET

INSTRUMENT:

Make & Model:____________________ Property No:______________________________
Serial No:__________________________ MFC SERNO: ___________________________
Date:______________________________ MFC Range:______________________________
Temperature:__________________°F______ Barometric Pressure:____________________mmBar

PRIMARY FLOW STANDARD:

Make & Model:____________________ Property No:________________Serial No:_____
________ Date Certified:__________________________ Cert. Expires:_______________
____

0-30 sccm MFC: Airflow = _________________ X Display ± _______________sccm
0-100 sccm MFC: Airflow = ________________ X Display ± _______________sccm
0-10 slpm MFC: Airflow = ________________ X Display ± _______________slpm

ZERO AIR:

Source:____________________________ Property No:______________________________
Outlet Pressure:____________________psig

SET POINT NO.	SET POINT (slpm or sccm)	MFC FLOW VALUE (slpm or sccm)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		

Calibrated by:_____________________________ Checked by:______________________________

Figure K.6.2 Mass Flow Controllers Characterization Datasheet